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Methods of Studying the Effect of Preservatives and other Substances Added to Foods upon Health and Digestion.*

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Food experiments have been conducted from remotest antiquity, but perhaps not with all the scientific accuracy which characterizes the experimental work of modern times. The first recorded food experiment which I have been able to find is described in the Book of Daniel, first chapter, twelfth verse and following.

When Daniel was brought into the royal household of the King of Babylon he was required to eat the food prepared for the King and the court. This the prophet was not willing to do. The chief of the eunuchs, who had taken a great fancy to Daniel, was greatly worried over the situation and informed the recalcitrant Israelite that the King

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would hold him responsible for the poor physical condition which Daniel would doubtless acquire if he failed to eat of the rations prepared for him. Daniel thereupon proposed an experimental test, based on a truly scientific principle, though not attended with that nicety of chemical analysis which to day is the primary condition of such work. He said to the prince of the eunuchs:

> Prove thy servants, I beseech thee, ten days, and let them give us pulse to eat, and water to drink. Then let our countenances be looked upon before thee, and the countenance of the children that eat of the portion of the King's meat; and as thou seest, deal with thy servants. So he consented to them in this matter and proved them ten days. And at the end of ten days their countenances appeared fairer and fatter in flesh than all the children which did eat the portion of the King's meat. And in all matters of wisdom and understanding that the King inquired of them, he found them ten times better than all the magicians and astrologers that were in all his realm.

Pulse, we find, is a thick pap or pottage made from meal, presumably the meal of leguminous seeds, such as peas and beans or other similar leguminous plants. At the present day, in the light of modern investigations concerning nutrition, we should be inclined to think that Daniel's ration was a very narrow one, in which the carbohydrate element was decidedly deficient. We are surprised also to learn that on such a diet, which is not regarded as flesh-producing, their countenances became fatter than those of the children who ate of the King's meat. If we should construe the language literally our surprise would not be so great, because "meat" might be particularly lean meat and thus the ration of the King's children be even narrower than that of Daniel and his fellows. But this we are hardly justified in doing, since the term "meat" is evidently used in this sense as a general expression for diet in which, presumably, the carbohydrates bore a prominent part. In one respect at least I have followed pretty closely the line of experiment which Daniel outlined some three thousand years ago, in that I have made the periods of experiment approximately ten days.

In the experiments which I am about to describe, however, instead of pulse and water being the principal items of diet, I have substituted therefor borax and boracic acid. According to newspaper reports, which unfortunately are

not always reliable, the results of my experiments have been very similar to those of Daniel, since it has been proclaimed from one end of the country to the other that the children of "borax," when their countenances were looked upon, were shown to be pinker and fatter than those of the children of pork and beans. So general has this impression become, that one of the distinguished members of the Supreme Court, Justice Brewer, remarked at an after-dinner speech not long ago, that he felt in looking at the fair, rotund faces of the guests that he might be addressing Dr. Wiley's borax boarders.

My purpose in the present address is to outline the nature of the experiments which have been conducted, to call attention to previous experiments of a similar character and note the points of difference and to refer briefly to some of the facts developed in the work. It is not possible at this time to give conclusions relating to the experimental work, because the analytical data, immense in quantity, have not yet been tabulated, averaged, and digested. It would be unwise to put forth any preliminary conclusions until all the data referred to are in shape for a careful study and comparison.

The primary object kept in view in the experiments which we are conducting is to determine by strictly scientific means the effect of preservatives, coloring matters, and other substances added to foods, upon the health of the consumer and upon digestion. We find in literature the most varied opinions of experts, so-called, concerning these matters. Practically every substance which has been used in foods for any purpose, aside from the foods themselves, has been the object of condemnation on the one hand and of praise on the other. Salicylic acid, formaldehyde, borax, sulphurous acid, and benzoic acid, all have their apostles who declare their use in preservative quantities not only harmless, but positively beneficial. On the other hand, we find another set of experts who indiscriminately condemn the use of any preservative or coloring matter whatever. We must be allowed to say that the burden of proof should fall upon the advocates of preservatives and coloring mat-

ters. It is not claimed that these are substances natural to food and their addition must therefore be positively justified. Negative results are condemnatory. If these bodies do no good they have no reason of existence; if they are injurious they should surely be prohibited; if they are beneficial under certain conditions, these conditions should be ascertained and definitely fixed.

In arranging for the experiments, in carrying them out, and in discussing the data, an earnest effort has been made to put aside every theory or personal inpression or prejudice connected with the subject. How many times have I been asked: "Are the experiments proving what you expected them to?" I can always answer this question negatively because I had put aside, before beginning the experiments, all expectations. Our object has solely been to ascertain the facts, to establish them if possible beyond cavil, to collate them in what seems a scientific and reasonable manner, and at the end to draw such conclusions as judgment, uninfluenced by prejudice, would approve. Some of the above purposes, it is hoped, will be fully accomplished, because we propose to set forth in detail the manner in which the experiments were conducted, to record all the facts observed just as they occurred, to tabulate the work in the most scientific manner possible, and thus present to competent experts a basis for conclusions. When all this is done it is evident that different conclusions may be derived from the premises by different persons. Whatever our conclusions may be, therefore, we do not claim for them any special virtue, but we do hope so to establish the facts on which they are based that the necessity for a repetition of the work may be relegated to the remote future. The enormous amount of work connected with such experiments and the great expense which necessarily attends them, render it extremely advisable that the work should be thoroughly done, with every possible regard for accuracy, with elimination as far as possible of all sources of disturbance and error and with the establishment on as firm a basis as possible of the recorded observations.

An outline of the method of making the experiments at

this time will be useful in explaining the details of the work, so that when the full data are published later, those who care to look into the matter can understand exactly how they were obtained.

First of all, it is evident that no mere theorizing on the chemical and physical properties of preservatives and coloring matters can be of much value in work of this kind. It is further evident that pharmacological experiments made upon any other animals than man, valuable as they are, will not lead to absolutely definite results. It is well known that the digestive organs of other animals are different from those of man; that the processes of assimilation vary, and that what might be innocuous to such an animal might in other circumstances prove harmful to man, and vice versa. It was therefore concluded that the experiments to be of full value should be made upon the human animal. Fortunately the Department of Agriculture is richly provided with subjects for experiments if only their consent thereto can be obtained.

First of all, therefore, a statement was made of the object of the experiments and this was submitted to a number of young men connected with the Department who were generally college graduates or students engaged in scientific pursuits, but at a low rate of compensation. The only inducement offered to these young men to engage their attention and consent, in addition to the contributions to the progress of science which they would make, was that of free board during the period of the experiment. This, indeed, must be considered as a very small reward for the strenuous life which they were compelled to lead for so long a period. Nevertheless, large numbers of volunteers presented themselves, far in excess of the actual demand. Each applicant was requested to fill out the blank which follows:

Descriptive blank to be filled out by applicants for Hygienic Table.

1. Name and address.
2. Date of birth.
3. Have you had any sickness confining you to your room within a year? If so, state nature and duration.

4. Are you subject to indigestion? If so, state character and frequency.

5. Do you use coffee, tea, or chocolate with your meals? If so, state at which meals and what beverage you prefer.

6. Do you use tobacco? If so, state in what form, at what times, and quantity.

7. Do you use wine, beer, or other alcoholic beverages?

8. Do you go to stool regularly? At what hours?

9. At what hours do you usually urinate?

10. At what hours do you go to bed? How many hours do you usually sleep?

11. Do you engage in any unusual or violent exercise? If so, what?

The object of the above blank was to get an idea of the personal habits of the applicant and especially to ascertain if he had been lately subject to any serious disease or if he had any hereditary tendency to disease. It was also desirable to know whether the applicant was addicted to the use of tobacco or of alcoholic drinks, and if so, to what extent. I had hoped to be able to secure a sufficient number of applicants who used neither tobacco nor alcohol to make up the corps of cadets, but in this I was unsuccessful. Only a very small percentage of the applicants used neither tobacco nor alcohol. Since alcohol has a positive food value, and it was desirable to eliminate this beverage from the hygienic table, I finally decided to reject the application of all those who used even to a moderate degree alcoholic beverages. I then decided to accept, in so far as it was necessary to make out the number, the applications of those who used tobacco moderately.

It was decided at the beginning that the number at the experimental table should be twelve, divided into two classes of six each. It was evidently impracticable for a young man to continue for seven or eight months in so strenuous a life at so small a compensation. The object of having two classes was that one should be resting while the other was undergoing experimental treatment, thus dividing the time as nearly as possible equally between the two. The number under experiment was subsequently increased to four-

teen for some special purposes. The members of the table having been selected, each one was required to subscribe to the following pledge:

I hereby agree, on my honor, to follow implicitly the rules and regulations governing the hygienic table of the Bureau of Chemistry during the time that I am a member thereof. I agree, during my attendance at the table of observation, to use no other food or drink than that which is provided for me, with the exception of water, and that any water not used at the table will be measured and reported daily as a part of the ration. I further agree that I will continue to be a member of the hygienic table for a period of at least six months, from December 1, 1902, unless prevented by some illness, accident, or unavoidable absence. I agree to continue the regular habits of my life, to indulge in no unusual excess of labor or exercise, and if tobacco be used it shall be used at such times and in such amounts as will be agreed upon between myself and the Chief of the Bureau of Chemistry.

I further agree that I will not hold the Department of Agriculture, nor any person connected therewith, responsible for any illness or accident that may occur during my connection with the hygienic table.

It is evident that in experiments on the human animal it is necessary to rely to a certain extent upon the honor of the person under observation. I have every reason to believe that the members of the hygienic table kept their pledges faithfully. They were young men of high standing, fine character, with no bad habits, and they all took a lively personal interest in the work to which they were devoting themselves. They were required, as is seen by the pledge, to pursue their daily vocations in the usual way. In the case of those who used tobacco, a statement of the quantities used, the character of the tobacco employed, and the times at which it was taken, was made, and they agreed to continue the use in exactly the same way during the entire period.

At the completion of an experimental period, in retiring from the experimental table and passing to the recreation table, the candidate was required to subscribe to the following certificate:

I hereby certify on my honor that during the period beginning —— —— and ending ——, I have not partaken of any food or drink (except water reported) other than that furnished at the hygienic table of the Bureau of Chemistry, and that I have accurately recorded all the items of food and drink received at the table.

I further certify that I have not engaged in any excessive or unusual

physical exercise; that I have followed, in so far as possible, the regular tenor of my daily life in respect of work, exercise and sleep; that I have observed to the best of my ability and recorded accurately the data relating to weight, temperature and pulse; and that I have observed faithfully all the regulations connected with the experimental work at the hygienic table.

By thus placing the young men on their honor, by interesting them in the work, and by giving them periods of rest during which they were at liberty to eat moderately at other tables than those set in the Bureau of Chemistry, I secured practically the results which would have been obtained by an absolute control of animals experimented upon both during the periods of eating and the intervening periods.

It may be asked: Why were so many persons selected? To this I reply that the idiosyncrasy of the human animal is very marked. Experiments made upon a single, or even two individuals, are apt to be very misleading by reason of this idiosyncrasy. I would gladly have extended the experimental work to twenty, thirty, or even fifty, if it had been possible to do the analytical work connected with such a large number. One of the chief differences between the series of experiments under consideration and those previously made has been in this particular. We have experimented with a much greater number of subjects and for a much longer period of time than any of the similar experiments that have heretofore been conducted. We have thus, to this extent, eliminated more completely the errors due to imperfect observation, imperfect control and idiosyncrasy.

The installation of the kitchen was in one of the rooms of the basement of the Bureau of Chemistry, which up to this time has been used as a store-room. The cooking was done on two gas stoves and under the supervision of a cook certified by the Civil Service. The arrangement of the kitchen is shown in the projection which I now throw upon the screen.

The dining-room was one of the rooms set apart for the Road Material Laboratory which, however, could be used for the dining-room without interfering materially with the work carried on there, which was done chiefly at desks around the sides. An illustration of the dining-room is

shown in the projections which are now thrown upon the screen.

The food of each member of the table under observation was weighed or measured; the liquids, such as coffee, milk, tea and water, being measured and calculated to weight from the density of solutions; the solid foods being weighed upon a torsion balance sensitive to a half a gram. The process of weighing is shown in the illustration which is now projected on the screen.

A sample of the food furnished at each meal was taken for analysis, immediately placed in a bottle, stoppered and sealed with paraffin so that no moisture could escape in the necessary interval of time before weighing and subsampling of the sample could be accomplished. Foods which could be used in bulk, such as prepared cereals, etc., were sampled for each lot, thus reducing to some extent the labor of analytical work. The analytical work connected with the experiments was conducted in the food laboratory, and illustrations showing the general character of the work as conducted are now projected upon the screen.

Not only did the analytical work include samples of all the foods used for each meal, but also samples of the urine and feces, which were carefully collected and weighed for each of the members of the table and subjected to analysis. In short, an account was opened with each member of the table, exactly similar in character to a bank account. Each member was charged with all that was given him in food and credited with all which was returned in the excretions. The balance represented the food consumed in the production of heat and energy within the system provided the bodily weight remained constant. Thus an exact and accurate control was kept of each individual which would have made it impossible for him to have violated the rules by taking nourishment in addition to that given him, because all such additional nourishment would have at once been detected by a disturbance of the balance sheet. Each member of the observation table was weighed carefully on a delicate balance each day before dinner, since the determination of the weight of the body and its variations under the experiment

are two of the most important of the data to be obtained. Each member of the table was furnished with blanks, copies of which are projected upon the screen, with which to keep an account of the foods received, the meals at which they were eaten, to enter a record of his weight, of the temperature before and after eating, of the pulse, a record of the beatings of the heart, and all other data connected with the income and outgo of the food. One of these blanks was filled up for each meal and the daily blank filed. From these blanks a statement of the foods consumed was made for the same period of observation.

In the beginning of each experimental period there was first determined how much of the food would be necessary to secure as nearly as possible an even weight of the body. This part of the experiment was called the "fore-period," and lasted, after the manner of Daniel, for about ten days. At the end of this time the daily ration for each member of the table had been determined and this was established as the standard of the ration which we should have during the remaining portion of the experimental period.

The "middle period" represented that portion of the time during which each member of the table ate the rations previously determined, together with the added preservative, borax or boracic acid. This period extended generally from ten to fifteen days.

This was followed by the "after-period," during which the same ration as first determined continued, but the preservative was withdrawn, the object being to restore the body to its normal condition in case it had been disturbed by the use of the preservatives. The after-period as a rule was ten days in length. Thus the whole period under observation varied in each class from 30 to 40 days.

An illustration of the quantity of food eaten by a class under observation for one of the periods is shown in the photograph which is now projected upon the screen. The variations in bodily weight during a period of observation are most conveniently represented graphically. Such a representation covering one of the periods of observation is thrown upon the screen. It bears the graphic lines show-

ing the variations in the weight of each member of the class for a full period, including fore, middle, and after periods. It also shows a combination of these variations in a graphic line based upon the average weight of the members of the class at the time of entering upon a period of observation, with the variations of the average weight by combining into one the individual variations in weight for each day. Thus there is practically eliminated from this graphic line the accidental variations due to idiosyncrasy and error of observation, and the general effect produced in the different parts of a period are shown by the variations in this base line. A balance sheet showing the amount of food charged to each individual during a period of observation, together with the amount with which he is credited, showing the deficiencies or excess, is also thrown upon the screen. (During these projections the particular facts represented by each table and graphic chart were pointed out, without, however, drawing any conclusions of a general nature relating to the whole experiment.)

The above are illustrations of the character of the work which has been accomplished in the study of the effect of preservatives, coloring matters, etc., in so far as the experiments have now extended. When you consider the great amount of time required for each chemical operation, the vast total number of weighings of the food for the control of the work, the equally great mathematical labor of tabulating, computing, averaging, and studying the data for a period covering seven months, you can have some realization of the magnitude of the work which has been undertaken and that part of it which has already been accomplished. The table itself, with its steward, cook, waiter, members, and direction, required the continued services of eighteen persons, who had to work without intermission twelve hours a day, holidays and Sundays included, for the whole period. In the chemical work eight chemists with quite a number of aids were employed during the whole time. The tabulation work, which is not yet completed, has employed five or six expert computers for a period of two or three months and much is yet to be done. The actual cost of the food

consumed during the seven months has varied but little from $12 per month for each individual. When it is considered that we could not use the scraps and pieces, as is done in ordinary domestic kitchens, but that we had to select the homogeneous parts of the food, this is not an extravagant figure.

CONCLUSIONS DRAWN FROM EXPERIMENTS WITH BORAX IN REGARD TO ITS EFFECT UPON HEALTH AND DIGESTION.

I shall not undertake to give here a résumé of the literature relating to experiments conducted with borax and boric acid, but will content myself by citing the conclusions drawn from some of the more important observations which have been made.

I will begin with the conclusions of Chittenden and Gies, published in the *American Journal of Physiology*, volume 1, 1898. The experiments were conducted upon full-grown dogs, ranging in weight from 17 to 25 pounds. For the details of the experiment, the original paper is cited. The authors draw the following conclusions:

Moderate doses of borax up to 5 grams per day, even when continued for some time, are without influence upon proteid metabolism. Neither do they exert any specific influence upon the general nutritional changes of the body. Under no circumstances, so far as we have been able to ascertain, does borax tend to increase body-weight or to protect the proteid matter of the tissues.

Large doses of borax, 5–10 grams daily, have a direct stimulating effect upon proteid metabolism, as claimed by Gruber; such doses, especially if continued, lead to an increased excretion of nitrogen through the urine, also of sulphuric acid and phosphoric acid.

Boric acid, on the other hand, in doses up to 3 grams per day, is practically without influence upon proteid metabolism and upon the general nutrition of the body.

Borax, when taken in large doses, tends to retard somewhat the assimilation of proteid and fatty foods, increasing noticeably the weight of the feces and their contents of nitrogen and fat. With very large doses, there is a tendency toward diarrhœa and an increased excretion of mucus. Boric acid, on the contrary, in doses up to 3 grams per day, is wholly without influence in these directions.

Borax causes a decrease in the volume of the urine, changes the reaction of the fluid to alkaline, and raises the specific gravity, owing to the rapid elimination of the borax through this channel. Under no circumstances have we observed any diuretic action with either borax or boric acid. The latter agent has little effect on the volume of the urine.

Both borax and boric acid are quickly eliminated from the body through the urine, twenty-four to thirty-six hours being generally sufficient for their complete removal. Rarely are they found in the feces.

Neither borax nor boric acid have any influence upon the putrefactive processes of the intestines as measured by the amount of combined sulphuric acid in the urine, or by Jaffe's indoxyl test. Exceedingly large doses of borax are inactive in this direction, not because the salt is without action upon micro-organisms, but because of its rapid absorption from the intestinal tract.

Borax or boric acid, when given in quantities equal to 1·5–2·0 per cent. of the daily food are liable to produce nausea and vomiting.

Owing to the rapid elimination of both borax and boric acid, no marked cumulative action can result from their daily ingestion in moderate quantities.

At no time in these experiments was there any indication of abnormality in the urine; albumin and sugar were never present.

The next study to which I call your particular attention was made by Dr. Oscar Liebreich, professor in the University of Berlin. The results of the experiments were published as a bulletin in 1899. Dr. Liebreich made an exhaustive study of the literature on the subject up to the time of the conduct of his experiments. These experiments were made upon dogs, rabbits and guinea pigs. In general, the conclusions drawn from the study of the literature and experiments of other authors, and from his own with animals, as set forth by Liebreich, are favorable to the use of borax in small quantities in food products. He summarizes the whole of the matter in the following language:

Now, though severest criticism of medical observations, and experience won from experimental research, justify the conclusion that borax and boric acid are innocuous as preservatives of food, this assertion of course can only be valid within certain limits, a restriction which, however, applies to all victuals and drugs; for we know that medicines, admixtures of food, and even aliments, when taken injudiciously or in excess, cease to be wholesome and suddenly become injurious substances. And, moreover, if harm could be done by borax and boric acid used in the preservation of food, the immense quantities which have already been swallowed would have aroused the attention of medical men, particularly as boracic preservation is openly practised (as may be seen by the butchers' trade journals) and has been unreluctantly accepted by the working classes.

For the preservation of meat, boric acid is used in quantities of ½ to ¾ per cent.; of this a great part is lost in watering the meat, particularly in the smoking process, for instance, so that we may estimate ¼ per cent. as the maximum amount which reaches the system. Experience has proved that 12 decigrams (1·2 grams) of boric acid or borax, if taken in food daily, even for a considerable time, does not affect health injuriously. Even quantities

twice as large have not been proved injurious, scientific investigation having decisively demonstrated that these doses are far below the limit where deleterious action commences.

Whoever studies the numerous experiments of different investigators with care will end in taking the view of certain authors, a view which has been mentioned above in this discussion, viz., that borax and boric acid, far from being injurious to the human system, are really wholesome substances. But a far greater number of observations will be required before this can be conclusively proved.

Elaborate experiments with borax upon men were conducted by the Imperial Board of Health of Germany, under the supervision of Dr. E. Rost and others, and the results published as Official Documents from the Health Office, Volume xix, Section 1, in 1902. An elaborate review of the literature, with critical comments thereon, is found in this publication. Two men were selected for the experiment, for the details of which the original publication is cited. Dr. Rost's conclusions are distinctly unfavorable to the use of borax as a preservative medium. He discovered local effects in the reddening, inflammation and ulceration of the stomach and the immediately adjacent portions of the digestive canal. He also discovered the production of diarrhœa when doses of borax were not too small. Both with dogs and in the case of five grown men he found that the administration of borax or boric acid to the extent of 3 grams per day produces a diminution in the bodily weight. He found that the complete separation of boric acid from the body was effected very slowly, and that for many days, and with persons suffering from kidney trouble for many weeks, traces of the borax in the system were distinctly detected.

An interesting paper on "The Influence of Boric Acid and Borax upon the General Metabolism of Children," written by Professor Tunnicliffe, of London, and Dr. Rosenheim, was published in the *Journal of Hygiene*, 1901, where full details of the experiments can be found. The authors draw the following conclusions from their work:

Boric Acid.—(1) Small doses, up to 1 gram per diem, continued for some time, exert in healthy or delicate children no influence upon proteid metabolism. The assimilation of the proteid food was improved in one healthy child.

(2) The phosphorus metabolism was unaffected in all cases. The assimilation of phosphorus was in all cases improved. (3) The assimilation of fat was not affected. (4) The body weight increased in all cases. (5) The quantity of feces was not affected. Their nitrogen and phosphorus percentage was slightly decreased. (6) No inhibitory effect upon intestinal putrefaction could be demonstrated.

Borax.—(1) Continued doses of 1·5 grams have no influence in heal hy or delicate children upon proteid metabolism. The proteid assimilation was unaffected in healthy childreu, slightly depressed in the delicate child. (2) The phosphorus metabolism was not affected in healthy or delicate children. The assimilation of phosphorus was improved in all cases, the amount being least marked in the case of the delicate child. (3) The fat assimilation was improved in the case of the others. (4) The body weight was increased in all cases; the increase was most marked in the case of the delicate child. (5) The weight of dry feces and their nitrogen and phosphorus percentage remain unaltered. (6) Borax tended rather to increase intestinal putrefaction.

Boric Acid and Borax.—Both boric acid and borax were quickly eliminated, no cumulative action being therefore probable. (2) Neither boric acid nor borax in any way affected the general health and well-being of the children.

Prof. Victor C. Vaughan and Mr. William H. Veenboer, of the University of Michigan, have conducted interesting experiments with borax as an antiseptic, and reviewed also the work of other investigators on the subject, the results of their investigations being published in *American Medicine* of March 15, 1902. From the results of their work they draw the following conclusions:

(1) The use of borax or boric acid as a preservative in butter and cream in the quantities specified in the recommendations of the English Commission is justified both by practical results and by scientific experimentation.

(2) The dusting of the surfaces of hams and bacon which are to be transported long distances, with borax or boric acid, not exceeding 1·5 per cent. of the weight of the meat, is effective and not objectionable from a sanitary standpoint.

(3) Meat thus dusted with borax or boric acid does not become slimy because the preservative thus used prevents the growth of aerobic, peptonizing microorganisms.

Dr. Liebreich published a second bulletin in 1902, detailing additional experiments with men and animals and dealing particularly with the report of the Imperial Board of Health of Germany before mentioned. This second publication of Dr. Liebreich sought to establish, by experimental data and otherwise, the conclusions given in his first

publication and contained in addition thereto an exhaustive critique of the report of the Imperial Board of Health.

This bulletin of Dr. Liebreich was answered in an exhaustive brochure entitled "Boric Acid as a Preservative," and printed as an official document of the Imperial Chancellor in 1903, in which Dr. Rost summarizes the results of the critical study of Dr. Liebreich's investigations and gives a restatement of the conclusions established by his own work in the following language:

> Boric acid is a preservative of small disinfecting power and can protect food from decomposition only by the use of proportionally large quantities. It is deceptive in its character in that it at once both increases the weight of the wares offered for sale and also makes it possible for the flesh with which it is mixed to hold a larger quantity of water than is possible when the flesh is pickled with salt or smoked. Even a still larger addition of this preservative does not betray itself to the person consuming it, either through the taste or through the odor. It has a direct injurious effect in that on the one hand it produces a lower assimilation of meat foods by the human body, and on the other hand it so influences the nutrition of man as to produce a diminution in bodily weight. In this connection it should also be noted that the complete separation of boric acid from the human body requires a very long period. What has been said of boric acid is essentially true also of borax.

Dr. Charles F. Dight, of Minneapolis, has published a pamphlet entitled "A Study of the Effect of Borax and Boric Acid on the Human Body," dated 1902, in which he reviews the work of previous investigators and details his own experiments conducted with pigs. For the details of the work the pamphlet cited can be consulted. As a result of his work he reaches the following conclusions:

> Now, the decisive test of anything is in the trial of it. The test of borax and boric acid, as made by various feeding and other experiments followed up by after-death examination, and these supplemented by the therapeutic use of borax and boric acid, give answer with the fullest certainty as to their effect in moderate amounts upon the animal body, and justify the following conclusions:
>
> (1) That borax exerts no specific action upon the animal body.
>
> (2) That any effect it exerts is because of and by virtue of its mild alkalinity.
>
> (3) That the sum total of its effects upon digestion is not harmful.
>
> (4) That it exerts no ill effect upon the ingredients of the blood.
>
> (5) That it does not act as an irritant to the tissues generally or locally, nor cause pathological congestions.

(6) That by its use nutrition is not impaired.

(7) That it does not increase proteid metabolism.

(8) That it is not cumulative within the body.

(9) That borax in moderate amount, 2 grams or more daily, exerts no ill effects upon the adult body.

(10) That in proportion of 0·5 per cent. it preserves fresh sweet meat from putrefaction for long periods of time, extending into months; while smaller quantities, even to 0·1 per cent. or less, have been shown in practical use to preserve for periods of less duration.

(11) That putrefaction once begun is not arrested by it nor its further progress checked.

(12) That it is not a deodorant, removing from or concealing in putrefying meats, the offensive odor.

(13) That all of this is true of boric acid also, except that any effect it exerts is by virtue of its mild acidity.

(14) That boric acid may be taken in larger quantities than borax without harm.

(15) That borax and boric acid, like anything naturally good, may become harmful when taken in excess.

The above citations will be sufficient to show the discrepancy which exists among the results obtained in experimental work with this most interesting body. The extended use of borax and boric acid in food products, especially in meats, milk, and butter, makes them perhaps of greater importance from a hygienic and legal point of view than any of the other preservatives in common use. The great difficulty of controlling experiments of the kind which have been detailed, the idiosyncrasies of the individual on whom they have been tried, and the difference between the action of this preservative on the human digestion and that of the lower animals, is sufficient to account for the greater part of the discrepancies which have been mentioned. Just to what extent the data which we have obtained in our own work will corroborate the views of one of the other schools of experts remains to be seen.

I may close, however, with a few general statements, not conclusions derived from my work but based upon a careful study of the work of others.

Foods can be preserved for a reasonable length of time in most circumstances without resorting to any chemical preservative of any kind. Simple sterlization, which can be applied to most foods, is the most effective and the least

objectionable of all forms of food preservation. There may be occasions of emergency or exigency in which the use of a chemical preservative is rendered imperative. The short period over which such an emergency would extend would not seriously endanger the health of the consumer were he to eat food for a brief period containing any one of the principal preservatives in common use.

It may be, further, a wise policy not to inaugurate absolute prohibition against all preservatives, but it certainly is true that wherever for any reason a preservative must be used the package of food containing it should be clearly marked so that the purchaser and the consumer may be fully informed regarding the matter.

Preservatives which even in small quantities when taken over a long period of time produce deleterious results should not be used in any case where it can be possibly avoided, and they should be permitted only in those cases of exigency and emergency where food cannot be properly preserved by any other means.

National and State legislation should be brought into harmony in matters relating to preservatives and colors so that laws may be uniform, based on sound hygienic and business principles, free of any tendency to prosecute or annoy, and supported by an enlightened public opinion, both on the part of the producers and consumers of food.

I have thus endeavored to set before you the general principles and some of the details of operation of the experiments conducted, and will close by saying that the complete detailed work of the first series of experiments, it is hoped, will soon be ready for publication. Then the second series of experimental work will be begun, following the same general method as that which has been outlined. I believe that you will agree with me that it is only by such an exact, painstaking, and long-continued labor as that which has been outlined that we can reach any safe and lasting conclusions in regard to the particular effects of preservatives, coloring matters, and other substances added to food, upon health and digestion.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, October 21, 1903.

The Belmont Filtration Works.

By John W. Hill.
Chief Engineer Bureau of Filtration, Department of Public Works, Philadelphia.

(*Concluded from p. 110.*)

ADMINISTRATION BUILDING.

(Contract No. 42.)

The Administration Building, *Figs. 24* and *25*, is located on the west side of the main court, between Filter No. 6 and the first installation of preliminary filters, and contains on the ground floor a boiler-room, engine- or pump-room, an office and a shelter and locker-room for the men employed about the station.

The second floor over the office will be fitted up for a laboratory for the technical examination of water samples from these and the Roxborough filters, and the basement under the office end of the building will be used as a store-room for tools and supplies.

In the pump-room are placed (under Contract No. 40-A) a set of centrifugal pumps to supply subsided water to the preliminary filter-house to wash the sandbed, and, if desired, also to draw off the water from above the sandbeds of low-level filters, and pump it into the supply pipes of high-level filters (thus avoiding the waste to the sewers of pre-filtered water); a set of duplex direct-acting pumps (furnished under Contract No. 40-B) to take water from the main effluent pipes of the filters, and pump under pressure of 80 to 90 pounds to the sand ejectors and sand washers; and the driving engines, electrical generators and main switchboard (furnished under Contract No. 46) for the electric lighting equipment of the works.

The boiler-room contains four internally-fired marine boilers, each of 200 commercial horse-power capacity. The

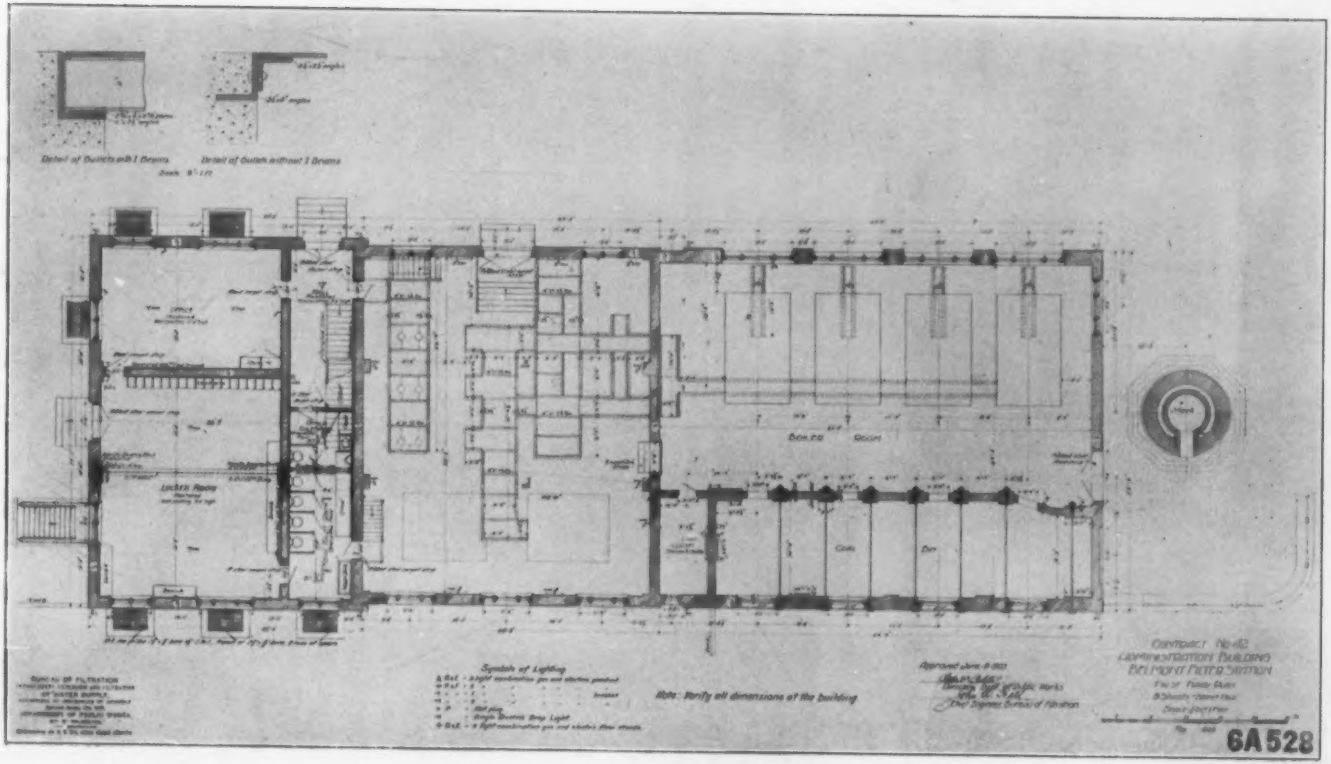

FIG. 24.—Plan of Administration Building and pumping station.

FIG. 24.—Plan of Administration Building and pumping station.

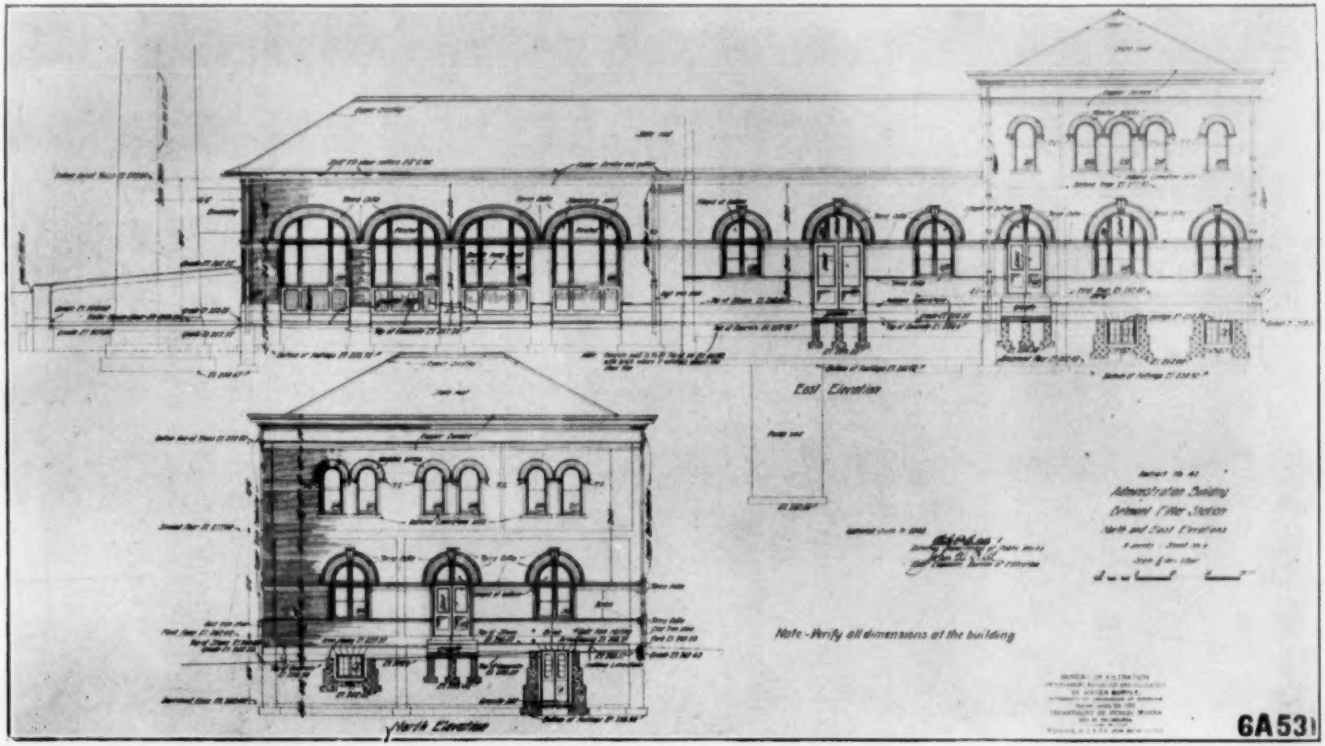

FIG. 25.—Administration Building. Elevations.

steam power developed will be used partly to pump wash-water to the preliminary filters, partly to pump water to the sand ejectors and washers, and partly to furnish the electric-lighting service for the station, and finally for steam heating of the building.

A "Custodis" chimney, 5 feet 6 inches diameter, 125 feet high, is erected at the south end of the Administration Building.

Fig. 25 shows the east and north elevations of the building. Good lines and substantial construction are the sole objects sought in this detail of the work. Referring to the left end of the front elevation, it will be noticed that the large windows in the rear wall of the boiler-room opposite the boilers, are arranged for complete removal, to permit of taking out or putting in boilers without injury to the brick-work or finish of the room.

The architectural features of the Administration Building are intended to match with the regulator and gate-houses about the filters.

HAND-TRAVELING CRANE.

(Contract No. 65.)

In the pump-room of the Administration Building will be placed a 6-ton hand-traveling crane to facilitate the erection of the pumping and electrical machinery, and for use in making the usual adjustments and repairs to the machinery.

SAND EJECTORS AND WASHERS.

(Contract No. 63—For sand washers only.)

The Belmont station will be equipped with four portable sand ejectors, and eight stationary sand washers, the latter located in the courts convenient to two or more filters.

The sand ejector, as shown in *Fig. 26*, consists of the well-known Korting ejector, mounted in the bottom of a metal hopper. Two lines of waterpipe are connected by ordinary fire hose, with the nozzle and throat extensions, one to supply water under pressure to operate the ejector, and the other to conduct the mixed sand and water from the ejector

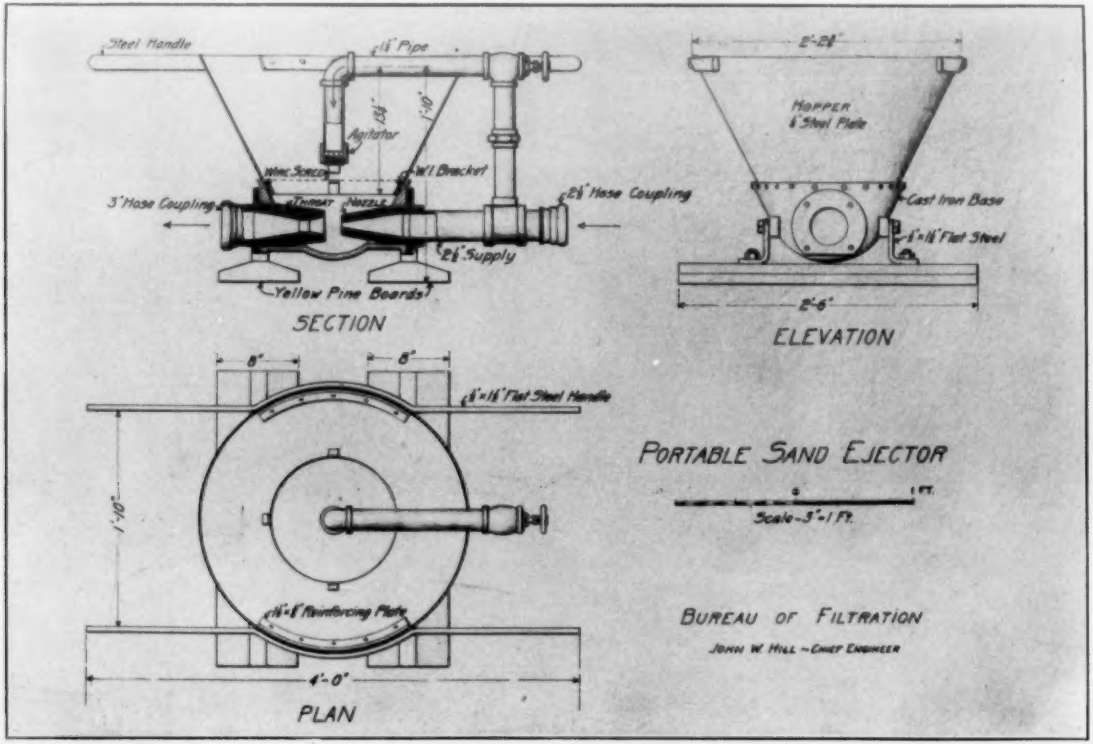

FIG. 26.—Portable sand ejector.

FIG. 27.—Portable sand ejector in service.

to the washer located in the court outside the filter. The water is brought to the ejector through a 2½-inch line of hose, and the mixed sand and water taken to the washers through a line of 3-inch hose.

A similar device has been used at the East London Waterworks for several years with excellent success in the rapidity and cost of transporting and washing the sand.

In the construction adopted by the Bureau of Filtration, the entire apparatus, as shown, weighs about 160 pounds, and two men can readily lift and carry the ejector from place to place in the filters convenient to the connections for the supply of water to the apparatus, and for the removal of the mixed discharge to the washers.

In practice the sand is scraped in a heap in each bay of the filter, and the ejector located so as to command at one setting twelve or more heaps. When placed in position the services of two men are required to feed the scraped sand to the ejector.

One ejector will easily throw out from the filter to the washer from 6 to 8 cubic yards of dirty sand per hour. The ejector not only transports the sand to the washer, but, during the trip through the discharge pipe, about one-half of the washing process is accomplished by the time the sand arrives at the washer.

The little ejector, shown in *Fig. 27*, with the services of two men to supply the sand, and a foreman to connect and disconnect the lines of hose to the water supply and discharge pipes, will accomplish in the same length of time the work of over twenty men with wheelbarrows.

The lines of wrought-iron water and discharge pipes are suspended by ordinary pipe hangers from the ventilator openings in the roof vaulting, and by standards resting on the "I" beams of the sand runs, with tees and nipples, as shown in *Fig. 28*, for the attachment of the lines of hose. At Upper Roxborough, and in due time at the other stations, these outlets in the waterpipes have been provided with gate stop-valves to reduce the time required to shift and connect up the ejector as it is moved from place to place in the filter.

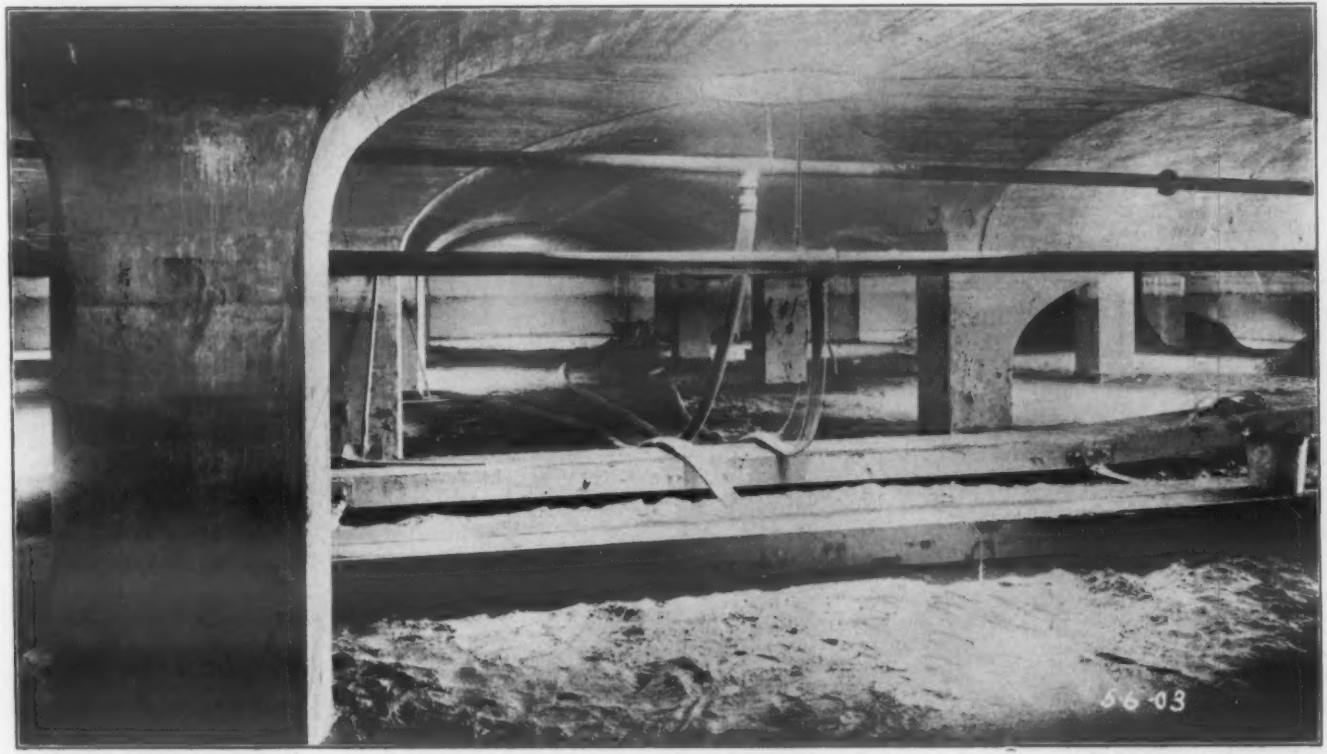

FIG. 28.—Portable sand ejector coupled up for use.

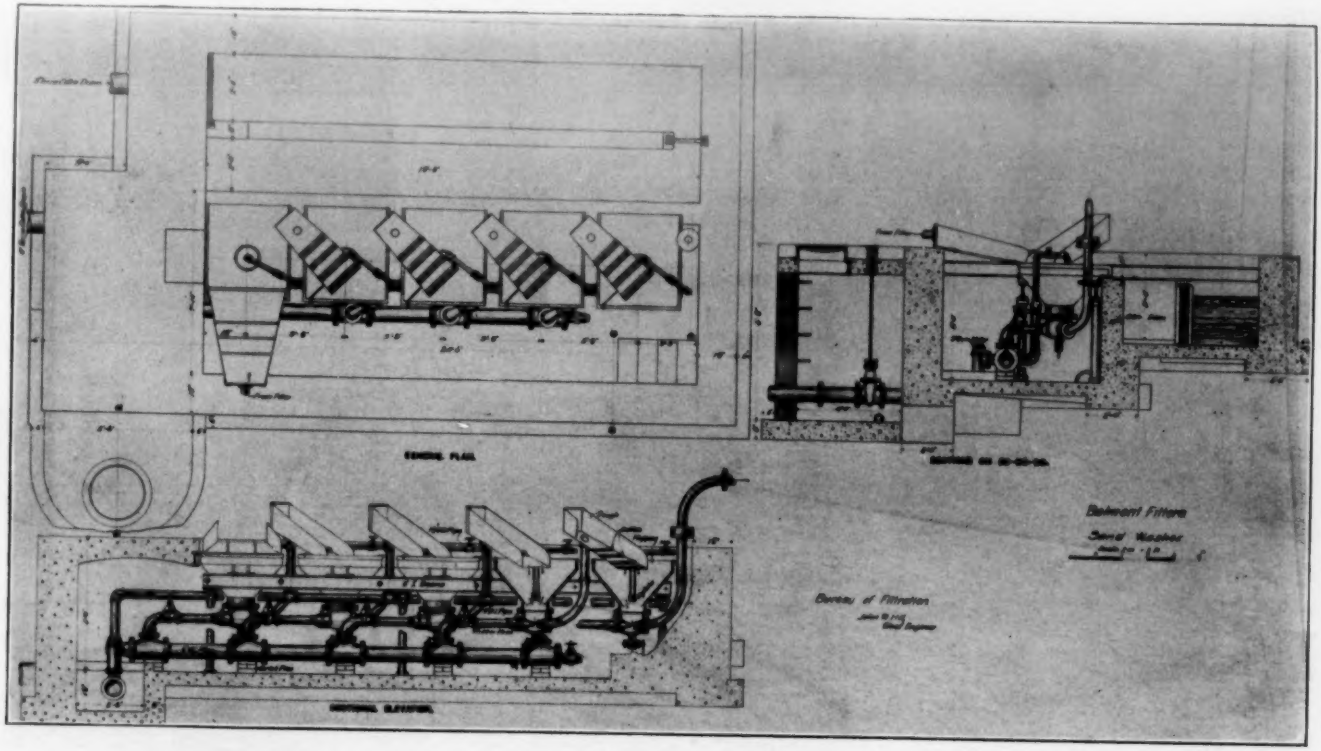

FIG. 29.—Plan of sand washer.

The consumption of water by the ejector is recorded by a 3-inch "Gem" meter placed on the water-supply pipe.

Fig. 29 shows in plan and section the type of sand washer adopted for the Philadelphia filters. This washer consists of a series of hoppers, each about 36 inches square at the top, into which is discharged the partially washed sand from the ejectors, where the ejector of the Korting pattern in the base of the hopper picks up the sand and lifts it into the trough, through which the water and sand flow over low baffles into the next hopper of the series. With the washing which takes place in the discharge pipes of the ejectors, two or three hoppers of the washer will suffice for the proper washing of the sand. From the last hopper of the series, the sand is discharged through a line of wrought iron pipe to the sand piles in the court. The sand-discharge pipe is provided with a swivel joint, which allows the pipe to be swept through a wide arc over the sand piles.

Each hopper at one side at the upper edge is cut down for its full width to form a weir over which the dirty water flows into channels alongside the washer. Baffles are arranged in the channels, which are intended to intercept the sand, while allowing the dirty wash-water to flow away to the sewer.

This washer originated in the Hamburg waterworks, and is there known as the "Schroeder" washer. Each washer is equipped with a "Gem" meter to measure and record the consumption of water.

At Lower Roxborough the sand washers were placed in houses constructed in the courts, but at Upper Roxborough and at Belmont the washers are set in the courts without houses, with the upper edges of the hoppers about flush with the granolithic pavement.

Fig. 30 shows one of the washers set in the court at Upper Roxborough, and the Belmont washers are being constructed in the same way. The open arrangement of the washers gives greater facility in their adjustment and use, and since no manual labor is required at the washer, except to adjust it occasionally and to distribute the washed sand over the piles in the court, no advantage was found

FIG. 30.—Upper Roxborough sand washers.

in the use of houses, such as were put up with the first washers at Lower Roxborough.

In operation the partially washed sand from the ejector working inside the filter is delivered into the galvanized iron trough shown at the left of the washer. Excepting the length of fire hose used to connect the ejector with the waterpipes in the filter, all other lines of pipe to the washer and to the sand pile are made of ordinary wrought-iron steam or gas pipe with flange joints.

Two sand ejectors and one washer combined will transport and wash from twelve to fifteen cubic yards of sand per hour, with an expenditure of 2,400 gallons of water per cubic yard of sand washed, and at a cost ranging from forty-four cents to sixty cents per cubic yard of sand for scraping, transporting and washing. Reduce this to gallons per cubic yard, the cost per million gallons for scraping, transporting and washing sand, after the mechanical appliances are properly adjusted, ranges from sixty-one cents to eighty-four cents per million gallons of water filtered.

ELECTRIC LIGHTING SYSTEM.

(Contract No. 46.)

The electric lighting machinery consists of two direct-current, constant potential, compound-wound six-pole generators (to be furnished by the Fort Wayne Electric Company), each having a capacity at 275 revolutions per minute of 37½ kilowatts at a potential of 225 volts at the switchboard in the engine-house, driven by two horizontal, self-oiling, center crank, direct connected engines (to be furnished by the Watertown Engine Company, Watertown, N. Y.). The engines will work under a steam pressure of 125 pounds per square inch at the throttle.

The current from the generators is carried to the Administration Building, preliminary filters, regulator houses at the filters, into the filters, to the gate houses of the sedimentation and clear-water basins, and to ten enclosed arc lamps placed on iron poles in the courts between the filters.

Each filter is equipped with 148 16-candle-power incan-

descent lamps. The double regulator houses are provided with six lamps, and each single regulator house is provided with four lamps.

The electric lamps in the filters will be used when it becomes necessary to perform some operation connected with the scraping, removal or restoration of the sand during the most severe weather of the winter, or at night time in case of emergency; and to guard against unusual delay, when filters are taken out of service, it was deemed wise to equip each filter with a system of lamps to admit of the work going on during any kind of weather day or night, with the ventilator covers in place, should the service at any time demand it. The Administration Building, preliminary filters, regulator houses of the filters and the gate houses of the reservoir will be illuminated nightly.

CAPACITY AND COST OF THE BELMONT WORKS.

The following table contains the several details and contracts entering into the construction of the Belmont works of filtration, not including real estate or extension of the pipe system for the distribution of the filtered water:

Contract No. 16.	Sedimentation basins	$670,000 00
	Clear-water basin	260,000 00
	Eighteen plain sand filters	999,000 00
	Contingencies (incurred and assumed)	71,000 00
Contract No. 38.	Preliminary filters (estimated)	160,000 00
Contract No. 40–A.	Centrifugal pumping machinery	7,300 00
Contract No. 40–B.	Direct-acting pumping machinery and steam boilers	29,000 00
Contract No. 42.	Administration Building and pumping station	55,000 00
Contract No. 46.	Electric-lighting system	20,000 00
Contract No. 49.	Lateral collectors, underdrains and filtering materials	365,000 00
Contract No. 63.	Sand washers	6,800 00
Contract No. 65.	Hand-traveling crane	2,700 00
Contract No. 67.	Preliminary filter house (estimated)	70,000 00
Total cost		$2,715,800 00

This shows that the cost, based upon an immediate capacity of 40,000,000 gallons of filtered water per day, amounts to $2,715,800, or $67,895 per million gallons.

In addition to the items mentioned above entering into the improvement of the works of water supply for West Philadelphia, over $1,300,000 has been expended for land for the filtration works, new pumping machinery, new engine and boiler house and electric lighting machinery and equipment at the Belmont pumping station; new rising pipes to the sedimentation reservoir, mentioned in this paper, and for extension of the pipe system.

The relative cost of the Belmont works, population considered, is greater than the Roxborough and Torresdale works for the supply of that part of the city lying between the Delaware and Schuylkill Rivers.

Thus the per capita cost of the Belmont improvements is in round numbers $23.53, while the per capita cost of the combined Roxborough and Torresdale works is $17.07.

The next step in the enlargement of the Belmont works will be to increase the capacity of the preliminary filters to 65,000,000 gallons per day, instead of 40,000,000 gallons per day as now designed. The total cost then becomes $2,865,800, or a cost per million gallons capacity of $44,087.90.

The ultimate capacity of the Belmont works, according to the studies of the Bureau of Filtration, will be 95,000,000 gallons per day of twenty-four hours, requiring an increase of the plain sand filters from eighteen to twenty-six (land for this purpose being available at the south end of the property taken by the city) and an increase of the preliminary filters from 65,000,000 to 95,000,000 gallons per day, making the total ultimate cost $3,489,800, or a cost per million gallons daily capacity of $36,734.70.

The present population of West Philadelphia is assumed to be 170,000, and the present consumption about 185 gallons per capita per day. If this rate of consumption continues the present capacity of the works will be sufficient for 216,000 people, or, according to the population curve for West Philadelphia, until 1912, and the capacity of the works when increased to 65,000,000 gallons per day will serve 350,000 people, which population should be reached by 1930, and with an addition of eight plain sand filters and a further increase of 30,000,000 gallons in the preliminary

filters, the works will serve a population of over 500,000 people, which population by the curve will be attained by 1945.

Assuming an allowance of 150 gallons per capita per day, the total population to be supplied and the cost per capita of population is shown in the following table:

For 40,000,000	gallons	daily,	266,666	population,	$10.15	cost	per	capita.
" 65,000,000	"	"	433,333	"	6.65	"	"	"
" 95,000,000	"	"	633,333	"	5.61	"	"	"

The dimensions and all material features of construction of the Belmont filters are substantially the same as for the Upper Roxborough filters; the source of raw water (the Schuylkill River) is alike for both. At this date no filters have been put in operation at Belmont, and it is therefore impossible to present the results of operation. In lieu thereof I am compelled to submit figures showing the performance of the different filters at Upper Roxborough since starting, July 3d of this year, which can safely be accepted as an index of what the Belmont filters will do when put in service.

In the following averages, and highest and lowest bacterial and chemical results, the first two weeks of performance of the filters is omitted. The experience abroad with plain sand filters indicates that from two to three months' time is required before the filters are in fair working service. At Upper Roxborough, however, with one or two exceptions, every filter was delivering an entirely satisfactory water within two weeks of the time it was started.

SCHUYLKILL RIVER AT SHAWMONT.

Week ending 1903.	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
July 4,	26,000	60							
" 11,	25,000	100	·053	·159	·014	·75	2·95	5·2	2·08
" 18,	14,000	25							
" 25,	33,000	170	·089	·215	·010	·79	6·15		
Aug. 1,	16,000	26							
" 8,	42,000	38	·095	·130	·010		2·40	4·5	2·10
" 15,	36,000	30	·064	·102	·010	·71	2·45	4·8	
" 22,	23,000	26	·046	·124	·013	·73	2·15		
" 29,	29,000	20	·041	·118	·012	·65	1·65	5·1	·90

Week ending 1903.	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
Sept. 5,	36,000	34	·101	·161	·011	·77	4·55	5·0	1·88
" 12,	18,000	28	·037	·115	·012	·91	2·15	5·0	1·16
" 19,	18,000	21	·018	·078	·013	·85	1·40	4·1	·88
" 26,	26,000	24	·034	·139	·015	·72	2·60	3·9	·96
Oct. 3,	43,000	12	·014	·103	·011	·71	2·30	6·7	·67
Highest,	43,000	170	·101	·215	·015	·91	6·15	6·7	2·10
Lowest,	14,000	12	·014	·078	·010	·65	1·40	3·9	·67
Average,	27,500	57	·053	·131	.011	·69	2·75	5·0	1·32
			APPLIED WATER.						
July 4,	18,000	16							
" 11,	760	31	·038	·141	·036	·74	2·50	5·0	1·26
" 18,	325	20	·061	·108	·040	·88	2·00	4·8	·74
" 25,	510	22	·059	·110	·032	·77	1·85		
Aug. 1,	2,300	14	·058		·022	·76	2·65		·65
" 8,	550	13							
" 15,	860	14	·029	·079	·012	·69	1·85	4·8	
" 22,	830	8			·010	·75			
" 29,	540	7	·023	·088	·008	·71	1·45		·30
Sept. 5,	860	14			·010	·73			
" 12,	820	13	·034	·115	·013	·85	2·30	5·1	·48
" 19,	750	11	·043	·099	·013	·87	1·65		
" 26,	780	11	·035	·083	·013	·82	1·50	3·8	
Oct. 3,	1,200	7	·030	·091	·012	.73	1.60		
Highest,	18,000	31	·061	·141	·040	·88	2·65	5.1	1·26
Lowest,	325	7	·023	·079	·008	·69	1·45	3.8	·30
Averages,	2,077	14	·041	·114	·018	·77	1·93	4.7	·68
			FILTER NO. 1.						
July 4,	680	4	(First week of service.)						
" 11,	670	2	·004	0·67	·000	·82	1.55		
" 18,	360	20	·061	·108	·040	·88	2·00	4·8	·74
" 25,	13	1	·004	·070	·001	·94	1.35		
Aug. 1,	19	1	·004	·058	·001	·92	1.60		
" 8,	9	1				·92			
" 15,	6	1	·001	·033	·000	·70	1·05		
" 22,	13	1				·82			
" 29,	8	1	·002	·048	·000	·94	·90		
Sept. 5,	21	1				·76			
" 12,	22	0	·006	·056	·000	·94	1.35		
" 19,	26	0 +			·000	·92	1·00		
" 26,	55	0 +	·002	·051	·000	·88	·80		
Oct. 3,	10	0 +			·000	·78	1·05		
Highest,	360	20	·061	·108	·040	·94	2·00	4·8	·74
Lowest,	6	0	·001	·033	·000	·70	·80	4·8	·74
Average,	46	2	·010	·053	·005	·86	1·23	4·8	·74

FILTER NO. 2.

Week ending 1903	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
July 18, (First week of service)	3,300	5	·023	·073	·002		1·90		
" 25,	63	5	·002	·066	·000	·88	1·45		
Aug. 1,	37	4	·032	·075	·002	·961	·75		
" 8,	13	3				·84			
" 15,	10	2	·002	·071	·000	·701	·10		
" 22,	12	1				·80			
" 29,	8	1	·001	·051	·000	·76	·90		
Sept. 5,	33	1				·76			
" 12,	21	1	·006	·050	·000	·92	1·35		
" 19,	170	0							
" 26,	17	0 +		·047	·000	·88	·90		
Oct. 3,	9	0 +			·000	·76	1·10		
Highest,	170	4	·032	·075	·002	·96	1·75		
Lowest,	8	0	·001	·047	·000	·70	·90		
Average,	33	1 +	·007	·049	·000	·74	1·02		

FILTER NO. 3.

July 4,	360	2	(First week of service.)						
" 11,	240	2	.004	·067	·000	·94	1·75		
" 18,	15	2	·019	·063	·002	1·06	1·35		
" 25,	16	1	·002	·050	·000	·84	1·35		
Aug. 1,	12	1	·006	·063	·000	·92	1·55		
" 8,	9	2				·88			
" 15,	9	1	·001	·046	·000	·76	1·00		
" 22,	5	1				·82			
" 29,	7	1	·002	·046	·000	·76	·90		
Sept. 5,	19	1				·76			
" 12,	30	0 +	·013	·057	·000	·92	1·20		
" 19,	14	0 +		·051	·000	·90	·95		
" 26,	29	0 +	.004	·052	·000	1·04	1·00		
Oct. 3,	14	0			·000	·88	·85		
Highest,	30	2	·019	·063	·002	1·06	1·35		
Lowest,	5	0	·001	·046	·000	·76	·85		
Average,	15	1	·005	·048	·000	·88	1·13		

FILTER NO. 4.

Aug. 8,	1,600	6	(First week of service.)						
" 15,	110	9	·002	.057	·000	·74	1·40		
" 22,	70	7				.80			
" 29,	31	2	·001	·044	·000	·72	1·05		
Sept. 5,	12	2				·80			
" 12,	12	1	·006	·058	·000	·92	1·70		
" 19,	29	1		·056	·000	·88	1·10		
" 26,	32	0 +	·002	·048	·000	·86	·75		

Week ending 1903.	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
Oct. 3,	170	0 +							
Highest,	170	7	·006	·058	·000	·92	1·70		
Lowest,	12	0 +	·001	·044	·000	·72	·75		
Average,	51	2	·002	·052	·000	·83	1·15		
			FILTER NO. 5.						
July 4,	390	5	(First week of service.)						
" 11,	410	6	·003	·069	·000	·92	1·80		
" 18,	38	4	·009	·063	·000	1·00	1·50		
" 25,	18	3	·004	055	·000	·84	1·40		
Aug. 1,	10	3	·007	·074	·000	·96	1·70		
" 8,	10	2				·88			
" 15,	8	2	·001	·039	·000	·76	1·25		
" 22,	12	1				·80			
" 29,	21	1	·002	·052	·000	·72	·85		
Sept. 5,	18	1				·76			
" 12,	Out of service.								
" 19,	99	1		·049	·002	1·10	1·15		
" 26,	7	0 +	·001	·033	·000	·86	·95		
Oct. 3,	6	0 +			·000	·82	1·10		
Highest,	99	4	·009	·074	·002	1·10	1·70		
Lowest,	6	0 +	·001	·033	·000	·72	·85		
Average,	22	2	·003	·046	·000	·86	1·24		
			FILTER NO. 6.						
July 4,	1,500	4	(First week of service.)						
" 11,	740	6	·006	·076	·000	·98	1·95		
" 18,	42	5	·005	·067	·000	·98	1·30		
" 25,	21	4	·008	·074	·000	·94	1·40		
Aug. 1,	14	3	·004	·062	·000	·88	1·80		
" 8,	27	2				·86			
" 15,	11	1	·002	·053	·000	·72	1·10		
" 22,	10	1				·86			
" 29.	10	1	·001	·024	·001	·78	·92		
Sept. 5,	59	1							
" 12,	220	1 -							
" 19,	21	0 +	·001	·035	·000	·84	1·20		
" 26,	6	0 +	·001	·044	·000	·90	·95		
Oct. 3,	7	0 +			·000	·84	1·10		
Highest,	220	5	·008	·076	·001	·98	1·95		
Lowest,	6	0 +	·001	.024	·000	·72	·92		
Average,	37	2	·003	·045	·000	·78	1·25		

FILTER NO. 7.

Week ending 1903.	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
July 4,	160	4	(First week of service.)						
" 11,	550	6	·004	·068	·000	·96	1·75		
" 18,	31	5	·008	·069	·002	·98	1·35		
" 25,	25	3	·002	·058	·000	·80	1·40		
Aug. 1,	17	5	·004	·070	·000	·84	1·75		
" 8,	13	3				·82			
" 15,	8	2	·002	·056	·000	·82	1·35		
" 22,	10	2				·84			
" 29,	180	1							
Sept. 5,	23	1				·76			
" 12,	8	1	.016	·062	·000	·84	1·70		
" 19,	6	1	.002	.041	·000	·82	1·10		
" 26,	9	1	·002	·044	·000	·92	·85		
Oct. 3,	7	1			·000	·82	1·15		
Highest,	180	5	·008	·070	·002	·98	1·75		
Lowest,	6	1	·002	·041	·000	·76	·85		
Average,	28	2	·005	·050	·000	·84	1·33		

FILTER NO. 8.

July 4,	1,000	2	(First week of service.)						
" 11,	2,400	4	·004	·064	·000	·90	1·50		
" 18,	23	2	·014	·066	·000	1·00	1·45		
" 25,	6	1	·004	·045	·000	·80	1·30		
Aug. 1,	7	1	·004	·063	·000	·94	1·40		
" 8,	6	1				·82			
" 15,	7	1	·001	·044	·000	·82	1·10		
" 22,	8	1				·88			
" 29,	4	1							
Sept. 5,	32	1				·92			
" 12,	8	1	.002	·059	·000	·88	1·55		
" 19,	19	0 +							
" 26,	23	0 +		·040	·000	·88	·85		
Oct. 3,	23	0 +			·000	·78	1·00		
Highest,	32	2	·014	·066	·000	1·00	1·55		
Lowest,	4	0 +	·001	·040	·000	·78	·85		
Average,	14	1	·003	·045	·000	·87	1·24		

CLEAR-WATER BASIN.

July 25,	340	3							
Aug. 1,	250	3							
" 8,	34	3							
" 15,	24	3	·002	·044	·000	·72	1·15	4·2	
" 22,	19	2				·80			
" 29,	140	1	·001	·054	·000	·80	1·05		·05
Sept. 5,	20	1							

CLEAR-WATER BASIN.

Week ending 1903.	Bacteria.	Turbidity.	Free Amm.	Alb. Amm.	Nitrites.	Nitrates.	Oxygen consumed.	Chlorine.	Iron.
Sept. 12,	41	1	·003	·045	·000	·88	1·65	4·6	·09
" 19,	42	1		·059	·000	·94	·90		
" 26,	24	0 +	·001	·041	·000	·86	1·00	4·7	
Oct. 3,	15	0 +	·002	·043	·000	·80	1·25		
Highest,	140	3	·003	·059	·000	·94	1·65	4·7	·09
Lowest,	15	0 +	·001	·041	·000	·72	·90	4·2	·05
Average,	40	1	·001	·047	·000	·82	1·16	3·3	·07

The sedimentation reservoirs, filters and clear-water basin for the Belmont works were bid for at lump-sum prices for each item, and for purpose of current estimates the unit prices in the following table were adopted:

PRINCIPAL QUANTITIES—BELMONT.

Quantities.		Items.	Unit prices for current estimates.
550,010	Cubic yards	Excavation (unclassified)	$ 1 00
319,420	"	Embankment and top soil	50
22,150	Square feet	Granolithic pavement	1 50
3,021	Tons	Hub and spigot pipe	41 00
419	"	Hub and spigot specials	94 40
331	"	Flange specials	100 00
261		Stop and check valves (various sizes)	
69,600	Cubic yards	Puddle	2 50
71,150	"	Concrete	6 00
47,800	Square yards	Asphalt lining	1 00
64,250	Pounds	Cast-iron fixtures	02
523,400	"	Steel	03
197,200	Square feet	Expanded metal	15

The contractors for the Belmont Works, Contract No. 16, sedimentation basin, filters and clear-water reservoir, were Messrs. Ryan & Kelley, of Philadelphia, with the Vulcanite Paving Company, of Philadelphia, sub-contractor for the concrete and asphalt work; R. D. Wood & Co., of Philadelphia, sub-contractors for cast-iron waterpipe and special castings; the Ludlow Valve Company, of Troy, N. Y., sub-contractor for stop, check and regulating valves and loss of head gauges; and the American Bridge Company, of Philadelphia, sub-contractor for structural steelwork.

Contract No. 40–A.	Centrifugal Pumping Machinery, R. D. Wood & Co., Philadelphia, contractors.
Contract No. 40–B.	Sand Washer Pumps and Boilers, I. P. Morris Company, Philadelphia, contractor.
Contract No. 42.	Administration Building and Pumping Station, Harry B. Shoemaker & Co., Philadelphia, contractors.
Contract No. 46.	Electric Lighting System, Pennsylvania Equipment Company, Philadelphia, contractor.
Contract No. 49.	Filtering Materials and Underdrains, Daniel J. McNichol, Philadelphia, contractor.
Contract No. 63.	Sand Washers, P. Gormly, Philadelphia, contractor.
Contract No. 65.	Hand-Traveling Crane, Alfred Box & Co., Philadelphia, contractors.

The original engineer field corps in charge of these works was formed with Mr. La Monte Lloyd as first assistant engineer in charge, and Mr. Thomas McE. Vickers, Mr. Charles H. Paul and Mr. Seth M. Van Loan second assistant engineers.

On the 1st of February, 1903, Mr. Lloyd was assigned to office duty in the City Hall, and Mr. Paul was promoted to first assistant engineer in charge of all Belmont contracts, with Mr. J. Lee Allen as second assistant engineer, and Mr. Robley A. Warner as third assistant engineer.

During the progress of the work, Mr. Vickers resigned, and Mr. Van Loan was assigned as first assistant engineer in charge of Contract No. 28—Lardner's Point Pipe Distribution System.

The cost of the engineering and inspection of this work, not including the work performed in the City Hall, in the preparation of plans, estimates, etc., will be, when completed, about 2·08 per cent.

The total time required to complete the work will represent about three years.

The first contract, Contract No. 16, Messrs. Ryan & Kelley, contractors, was started about the 1st of July, 1901, and excepting for unusual causes of delay the entire work should be completed by July, 1904. The average force employed by the contractors during good weather ranged from 800 to 1,000 men.

LENGTHENING THE USEFULNESS OF THE ELECTRIC GLOW LAMP.

The filament in glow lamps gradually diminishes in diameter in consequence of the slow volatilization of the carbon. According to the *Elektrotechnische Rundschau*, a German firm introduces into the glass globe certain chemical compounds with a high boiling point; these, under the influence of the temperature in the lamp bulb, slowly give off vapors containing carbon, which is deposited on the filament, thus making up to a large extent for the loss referred to above, and keeping the resistance and also the brightness of the lamp more uniform throughout its useful life.

FAILURE OF VOLAPUK.

A universal language—one that may be written and understood by all the human family—has been the dream of linguists for a hundred years. Various artificial languages have been invented to answer this purpose, the most notable being the "Esperanto," devised by Professor Zamenhoff, of Moscow, and "Spelin," by Professor Bauer, of Agram, Croatia. Both failed to become popular. As the result of the experiments that have been tried from time to time in this direction, it has become the general opinion that the world will not take up any artificial language until it is fully adopted by the English-speaking nations.

The attempt made to establish Volapuk as a universal language has, I am sorry to say, been a failure. Despite the efforts made by some of the leading linguists to create wide interest in the subject, the experiment did not result as we had hoped it would. The failure was due to the fact that the percentage of those who really need to know several languages besides their own is not yet sufficiently large to insure the success of a universal language.

Volapuk was the most practicable artificial language that had been devised for the purpose. It was invented by the Rev. Johann Martin Schleyer, of Constance, Germany, a celebrated linguist, and he worked out the vocabulary and other details more thoroughly than most of his competitors, so that it was an actual language in working order. It was found to work all right in practice, but not enough people could be found who were willing to devote their time to its mastery to make it a success.

The trouble was that Volapuk was from fifty to a hundred years ahead of its age. I am satisfied that some such universal language, greatly improved upon, perhaps, will one day be adopted by the leading peoples of the earth.

The Volapuk experiment was the most notable ever tried, either here or abroad. Thirteen years ago, when it was at the height of its popularity, no less than 265,000 persons had become familiar with the speaking and writing of Volapuk, and 150 societies had been formed for its propagation. While it was strong in Germany, Austria, Spain, France, Italy, Sweden, and Denmark, in the United States there were only 6,000 students of the new language.

Perhaps the chief reason why Volapuk was not taken up more extensively here was that our young men had not the patience to master a language that was not then in general use. They felt that French or German or Spanish was much more practical, and therefore much more desirable.—*Charles E. Sprague in the Washington Times.*

PHYSICAL SECTION.

Stated Meeting, held Thursday, October 1, 1903.

A Résumé of Our Knowledge of the Physical Properties of Current-Bearing Matter.

By Dr. Paul R. Heyl.

Any present or future hypothesis as to the nature of electricity or of electric conduction in matter must show itself capable of accounting not only for all the changes which a current produces in the matter which conducts it, but also for its failure to produce any alteration, where such is the case. It therefore becomes of interest to see what changes are produced in current-bearing matter, and in what respects the conductor remains unaltered. From this survey it is necessary to omit all reference to current-bearing gases, though much has been learned from the study of the phenomena they present, and, for brevity's sake, to confine ourselves to the probably less familiar cases of conductors and electrolytes.

We shall treat first of the length of a current-bearing conductor. The question whether there is any such change of length unaccompanied by a corresponding change in the cross-section has been considered by several persons. It will be seen at once that to distinguish such an effect in the presence of the general expansion in all directions due to the heating effect of the current is a problem of no little difficulty.

Edlund* heated wires by a current until they had reached a definite elongation, and estimated their temperature by means of their resistance. He found that the calculated temperature was not as great as it should have been to produce the given expansion, and concluded that there was a small elongation due to the current. His method required an accurate knowledge of the thermal coefficients of expan-

* *Pogg. Ann.*, **129**, p. 15, 1866; and *ibid.* **131**, p. 337, 1867.

sion and resistance, and his results were not accepted as conclusive, for the question was soon attacked anew by Streintz.* This experimenter brought his wires to a definite temperature both with and without a current, and compared the relative elongations. To effect this purpose he gave his wires a thin coating of stearin, heated them by a current, and noted the elongation at the instant when the stearin melted. To heat the wire without a current he enclosed it in a glass tube fitted with corks at the ends which served as an air jacket. This tube was contained in a larger tube, and the space between them filled with stearin. A third tube enclosed the whole, and between the outer and middle tubes there circulated a stream of hot water by which the stearin jacket could be kept at its melting point. He made thirteen experiments, and in twelve cases there seemed to be a slight expansion due to the current, while in one case there was an apparent shortening.

Exner† also experimented on this question. He cooled the lower half of his wire by passing it through a glass tube full of water, and heated the cooled and the uncooled halves alternately by a current. He found that the elongation of the cooled half was only 1 or 2 per cent. of that of the uncooled half; but since the stationary water-jacket and the wire it contains must both rise slightly in temperature when a current passes through the wire, this result was not conclusive.

The question was finally settled by Blondlot,‡ who by a most ingenious device succeeded in distinguishing between the thermal expansion and the suggested elongation due to the current. If a conducting sheet elongates, he says, without undergoing any corresponding increase in cross-section, any figure drawn on the surface of such a conductor will be distorted; and, in particular, an angle across which the current runs will suffer an increase in its magnitude. Blondlot used a brass ribbon thoroughly annealed. If such a ribbon

* *Pogg. Ann.*, **150**, p. 368, 1873.

† *Nature*, **13**, p. 452; also Wiedemann, *Lehre von der Electricität*, vol. ii, p. 409, where further references to original papers are given.

‡ *Comptes Rendus*, **87**, p. 206, 1878.

be folded once over and once under, as in *Fig. 1*, any elongation due to the current will increase the angle *A B C* and cause the ends *D*, *E* to separate. This effect may be multiplied to any desired extent by folding the long end *E* over and *D* under, repeatedly, until they are again parallel as in *Fig. 2*, giving an arrangement which, when slightly pulled out, may be approximately described as a sort of four-sided screw propeller. If the reader will fold a strip of stiff paper in this manner he will find a series of angles so joined that if each suffers a slight increase the effect is cumulative, and there is a twist in the whole spiral. Blondlot folded his ribbon into 200 such angles, arranged it in a vertical posi-

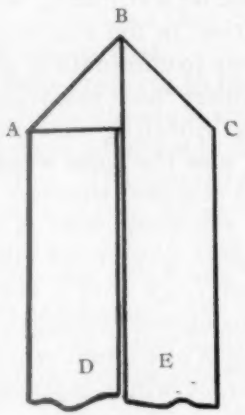

FIG. 1.

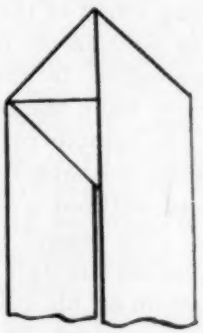

FIG. 2.

tion with one end soldered to a conducting support and the lower end dipping into mercury. A small mirror was affixed to the lower part. By observing from a distance the image of a scale reflected in this mirror the smallest twist could be detected. He used a current density of 370 amperes per square centimeter, and found that when the ribbon was carefully annealed there was no perceptible twist. He says he could have detected an elongation of 0·00025 millimeter. He does not state the length of his ribbon, but from the fact that he was able to fold it 200 times it must have been in the neighborhood of a meter long. Imperfect annealing or poor soldering of the upper

contact produced a slow twist in the wire which disappeared slowly when the current was stopped. This was evidently due to unequal heating, and serves to show the extreme delicacy of the method. The existence of an elongation or contraction unaccompanied by a proportional change in cross-section thus seems to be definitely disproved. The question of a change in volume by expansion in all directions, or (what amounts to the same thing) a change in the thermal coefficient of expansion due to the current, is left still open.

We shall next consider the elasticity of a current-bearing conductor. Wertheim* tested this in two ways, by Young's Modulus, and by the note produced by a vibrating wire, and found apparently a small diminution in the elasticity. He seems to have taken no precautions to eliminate or allow for the heating effect of the current other than remarking that the fall in pitch in the case of the vibrating wire could not have been caused by the heating, else the note would have risen slowly when the current was stopped, whereas it rose rapidly. A sample result on a vibrating wire is this: a copper wire, diameter 0·59 millimeter, gave 1,058 vibrations per second without a current, and 1,041 with a current of 7·8 units. We cannot identify this current strength to-day, as he chose for his unit that strength of current which gave 10° deflection on his galvanometer, of which instrument no description is given, but which, in the figures that accompany the original paper, looks like an instrument of the Melloni astatic type. The fall in pitch mentioned above is very small, about $\frac{1}{8}$ of a whole tone. Later investigations have shown that Wertheim's results are undoubtedly untrustworthy.

Streintz† experimented on the modulus of torsion, using stearin-covered wires, as in his length experiments. He found the time of vibration to be the same, whether the wire was heated with or without a current. He supposed at that time, from his length experiments, that allowance must be

* *Ann. de Chim. et de Phys.*, 1844 [3]; **12**, p. 610.
† *Progg. Ann.*, **150**, p. 368, 1873.

made for the current elongation, which would show a small change in the modulus; but as it is now known that no such elongation exists, his results are really negative.

Mary C. Noyes * investigated Young's Modulus. At first she thought that there was an irregular effect, varying with the history of the wire, such as the number of times it had been heated or had carried a current. In her second paper she adopted the method of measuring the temperature of the wire by its elongation. Apparently unaware of Blondlot's results, she remarks that some experimenters have found small changes in length due to the current, but that these were negligible. Measuring on this basis, which is probably entirely accurate, she found no perceptible effect on Young's Modulus other than that due to the accompanying heating effect of the current.

The next property to be considered is cohesion. Peltier † sent currents through wires of copper and iron for from 4 to 19¼ days, afterwards breaking them while no current was passing. It appeared as if copper was weakened by this treatment and iron strengthened. There are several objections to be urged in this connection, chiefly the long continued thermal effect, and the fact that pieces of wire cut from the same spool may vary several per cent. in tensile strength. The latter difficulty can be eliminated only by a large number of systematic observations.

Wertheim ‡ broke wires while the current was passing, and found that gold was apparently weakened about 40 per cent. He seems to have broken one such wire with the current and one without it. In a few experiments on iron and steel he found changes sometimes one way and sometimes the other, of the order of 2 to 10 per cent. His treatment of the subject is not sufficiently elaborate, and he says himself that he is unable to distinguish between the sought effect and the accompanying thermal effect.

The present writer has some experiments on this ques-

* *Physical Review*, **2**, p. 277, 1895, and **3**, p. 432, 1896.
† *Comptes Rendus*, **20**, p. 62, 1845.
‡ *Ann. de Chim. et de Phys.*, 1844 [3], **12**, p. 610.

tion in progress. They are not yet ready for publication; but, so far as he has yet gone, his results are negative.

It has always been assumed, without any definite experimental evidence, that the weight of a current-bearing conductor is unaltered. The writer suggests that this is hardly scientific, but savors rather of the older deductive philosophy. Faraday thought it worth while to test the question, but he was led in the course of his experiment to a new discovery, and never pushed his work to a definite conclusion. This will be referred to later. But while there seems to be no direct experimental evidence on this point, there is indirect evidence to show that there is no change in weight (at least, in copper wires) to the extent of about 1 part in 1,000. This evidence is furnished by work that has been done with the current balance.

It is interesting to notice that the first person to use a current balance (Cazin in 1864)* seems never to have thought that there was a possibility of the weight altering when a current passed, as his original paper is silent on this point. In this he was followed by greater names (Joule, Helmholtz). That this question was considered by Faraday, even if he reached no conclusion, serves only to add to his reputation as an exponent of inductive methods in science.

Probably the best work on the current balance is that of Lord Rayleigh and Mrs. Sidgwick on the electro-chemical equivalent of silver.† Their value for this constant is 0·00111794. Fr. and W. Kohlrausch‡ determined the same, measuring the current against the earth's field by an accurate tangent galvanometer. Their value is 0·00111183. Patterson and Guthe § measured the current against torsion, determining the latter by time of swing and calculated moment of inertia. Their value is 0·00111192. The close agreement of the first of these figures with the two others shows that no serious error could have been introduced by

* *Ann. de Chem. et de Phys.*, 1884, [4] **1**, p. 257.

† *Phil. Trans.*, [2], **411**, 1884; and *Proc. Royal Soc.*, **37**, 144, 1884. Also Rayleigh's *Collected Papers*.

‡ *Wied. Annalen*, **27**, 1, 1886.

§ *Physical Review*, **7**, p. 257, 1898.

the assumption that the weight of a current-bearing conductor remains unaltered. In pronouncing this effect negative it must be borne in mind that the current density in the coils of the current balance must be quite small, in order that thermal disturbances may be avoided. It would be an interesting though difficult research to determine what effect, if any, a heavy current has on the weight of the conductor. Any one contemplating such a research will find a useful suggestion on the weighing of hot bodies in a paper by the present writer in the *Journal of the Franklin Institute* for May, 1898.

Let us next consider the electrical resistance of a conductor. As the question of there being any resistance when there is no current flowing is rather a metaphysical one it will not be discussed here, but we shall limit ourselves to the effect produced on the resistance when the current changes from a vanishingly small magnitude to a very great one. The question may be put in this way: Is Ohm's law accurate, or is the ratio $\frac{E}{C}$ not a constant, but a function of the current? Schuster, in England, believed that some results of his with a sine inductor pointed to the conclusion that Ohm's law was inaccurate, and the British Association appointed a committee, of which Maxwell was a member, to test the question. Their report* describes two methods of experimenting, the theory of which is due to Maxwell, while the actual experiments were performed by Chrystal. In the first method five coils of nearly equal resistance (about 30 ohms) were employed. Their ratios were carefully measured, and it was found that this could be done to about one part in four millions. If two of these coils be balanced against each other in a Wheatstone's bridge, the coils occupying the two lower sides of a quadrilateral diagram, the current strength in the coils will be equal when there is no current through the galvanometer. Now replace one of these coils by a set of four, arranged two in series and two in parallel, and when no current flows through the galvanom-

* *B. A. Report*, 1876, p. 36.

eter the current strength in each coil of this set will be one-half that in the single coil in the other arm of the bridge. Consequently, if the resistance be a function of the current strength, the single coil will not balance the set of four. In carrying out this method it seemed that there was a falling off in the resistance of about one part in 200,000 when the current was doubled in strength; but a large part of this was afterward found to be due to defective insulation. As for the rest, the results of the second method make it certain that it must be attributed to some unrecognized error of experiment.

The theory of the second method is developed mathematically by Maxwell in the "Report" already referred to. He shows that if there be two conductors of the same material and different cross-sections arranged in series and carrying the same current, any departure from Ohm's Law will be greatest in the conductor of smaller section, and if their resistances be equal for small currents they will not be equal for large ones. The ratio of their resistances is expressed by the following formula:

$$\frac{L_1}{A_1}\ \frac{A_2}{L_2}\left\{1 + sC^2\left(\frac{1}{A_1^2} - \frac{1}{A_2^2}\right) + \ldots\ldots\right\}$$

wherein L_1 and L_2 are the lengths, A_1 and A_2 the sectional areas of the two conductors, C the current in both, and s the coefficient of departure from Ohm's Law, which is zero if the resistance does not vary with the current. It will be seen from this formula that (neglecting some small higher terms) the resistances may vary and their ratio remain constant, provided their areas are the same. Consequently the two wires chosen were made to differ greatly in area, and their resistances were made about equal by having the fine one short and the coarse one long. These wires were joined in series as two arms of a Wheatstone's bridge and a heavy and a weak current were sent through them in rapid succession (about sixty times a second) by means of a tuning fork. This served to eliminate the heating effect, or, rather, to keep the wires at a constant temperature for both currents, as the wire had not time to cool during the passage

of the weak current before the heavy one had returned. A balance was obtained with this intermittent current, and the weak current was then reversed in direction, the stronger remaining unaltered. The balance remained undisturbed. This could only have taken place if the resistances were independent of the current; for if the resistances varied no true balance could have been obtained in the first place, and what appeared to be a balance would have been merely a stationary needle under the influence of a rapidly alternating current, which would be converted into a direct (though fluctuating) current upon the reversal of the weak current before mentioned. As a result of this method the committee was able to state that when the current varied from a vanishingly small value up to one ampere per square centimeter the resistance did not vary by as much as one part in a million million!

There are few laws in physics whose verification has been pushed as far as this. In this case the natural limit of the solid continuity of the conductor was almost reached, as the strong current heated the fine wire beyond redness. This is the more remarkable, as Ohm's law was originally entirely empirical, without any theoretical reason to render it probable.

There are two substances, mercury and carbon, whose specific heats are known not to vary appreciably when a current is passed through them. For mercury this follows as a corollary to the work of Barnes and Cooke* with the continuous flow electrical calorimeter. In this instrument a slender thread of mercury was heated by the passage of a current and the results agree with the best results of earlier methods to about 1 part in 300.† For carbon the writer has shown† that the specific heat is not altered by 1 part in 450 for a current density of about 150 amperes per square centimeter. His method depended on the fact that a small abrupt change of temperature might be expected if the specific heat changed suddenly when the current was started or stopped.

* *Physical Review*, February, 1903.

† *Science*, July 10, 1903.

So far, all the effects of the current upon the properties of the conductor have been negative. There are a few positive effects. These are the well-known magnetic effect discovered by Oersted and amplified by Ampère; the three heating effects known by the names of Joule, Peltier and Thomson, respectively, and an alteration of the surface tension of a liquid conductor discovered by Faraday.* The latter was attempting an experiment on the weight of a current-bearing conductor, and had suspended a coil beneath a scale pan with one free end dipping into mercury. On starting the current the coil became much lighter, which Faraday found to be caused by the fact that the mercury was not so strongly drawn up around the wire when a current was passing.

There may also be an alteration in friction between two surfaces across which a current passes, as in Edison's motograph or chalk-cylinder telephone receiver. In this instrument a palladium surface rests upon a cylinder of chalk which has been soaked in a solution of sodium phosphate, and which is kept slightly moist and continuously rotated. When a current passes the palladium slips more freely over the chalk. An electrolytic explanation has been offered for this phenomenon, which supposes that gases developed in the solution carried by the chalk are occluded by the palladium. In favor of this there is the well-known property possessed by palladium for occluding hydrogen, and against it the fact that the instrument works best in the secondary circuit of an induction coil; also against it is the fact that the action is reversible, and a "motograph battery" has been constructed in which the friction of the palladium against the revolving chalk produced a current.

Passing now to the properties of current-bearing electrolytes, it has been shown by Faraday† that such a liquid has no effect on polarized light when the latter passes either across the current or in the same line with it. The electrolytes used were saturated solutions of sodium sulphate and lead nitrate.

* *Experimental Researches*, **2**, p. 256.

† *Experimental Researches*, **1**, p. 285, § 951 *et seq.*

Roiti,* Zecher† and Rayleigh‡ have investigated the speed of light in a current-bearing electrolyte with negative results. Zecher's paper the writer has not yet seen, as there is no copy of it in the Philadelphia libraries; but as Rayleigh remarks that his own work has been pushed farther than either of the others, it will be sufficient to consider his results. He used an interference method, employing dilute sulphuric acid and a current density of 0·26 amperes per square centimeter. He showed that for a current density of 1 ampere per square centimeter there could be no effect as great as 1 part in 13,000,000. He remarks that this result could be pushed somewhat further if there was any reason to expect an effect of that magnitude; but from the fact that the speed of light is 3×10^{10} centimeters per second and that of the swiftest ion (hydrogen) urged by a fall of potential of 1 volt per centimeter is about 10 centimeters *per hour*, the light wave could hardly be expected to know that the ions were in motion, the ratio of the speeds being something like one to ten million million.

Gladstone and others have shown§ that a current accelerates lagging chemical reactions, such as the precipitation of potassium acid tartrate and strontium sulphate; and Barus‖ finds that it also promotes the settling of suspended matter.

Mills¶ and Bouty** have shown that metals may be electrically deposited in films under tension or the reverse by properly choosing the current strength; and the latter finds that in the electrolysis of a number of salts ($CuSO_4$, $ZnSO_4$, etc.), a current strength may be found, so that for greater currents the negative electrode is warmed, and for less cooled by the separation of the metals. For the same salts may also be found a limiting current-strength, so that beyond it the separated metal exerts a pressure, and below it a pull

* *Pogg. Ann.*, **150**, p. 164.
† *Repertorium der Physik*, **20**, p. 151, 1884.
‡ *B. A. Report*, 1888, pp. 339–360.
§ *B. A. Report*, 1887, p. 667; also *Nature*, **36**, 524.
‖ *Bulletin U. S. Geological Survey* No. 36.
¶ *Proc. Roy. Soc.* **26**, No. 184, p. 504, 1877–78.
** *Comptes Rendus*, **92**, pp. 868–870, 1881.

upon that on which it is deposited. Moreover, these two neutral points are not identical for the same solution.

The present writer has shown* that crystals formed from a current-bearing electrolyte are not affected by the current, though they may be somewhat distorted by the accompanying heating effect in the liquid.

The foregoing seem to be all the properties of current-bearing solids and liquids that have been investigated. If any reader can supplement this bibliography, the writer would consider it a favor if he would do so, addressing him at the Central High School, Philadelphia. After reviewing what has been done in this field, many interesting research problems are suggested. Some of this work the writer has under way, and it would be well for intending workers in this field to correspond with him in order that useless duplication may be avoided.

HEAT WASTE FROM UNPROTECTED STEAM PIPES.

According to careful experiments made by Prof. S. P. Thompson, a square foot of uncovered steam-pipe filled with the vapor of 100 pound pressure will radiate and dissipate in a year the heat put into 3,716 pounds of steam by the economic combustion of 398 pounds of average coal. Thus, 10 square feet of bare pipe corresponds approximately to the waste of 2 tons of coal per annum. Another experimenter, testing the various materials employed for wrapping, concludes that the saving in condensation effected with the best form of mica covering is nearly 88 per cent.—that is, calling the loss of heat with bare pipes 100, the loss when wrapped with mica-packing would be 12. Asbestos covering seems to be considerably inferior to mica, and cements less desirable than either.

WATER JET AS A CURRENT CARRIER.

The danger from electricity, particularly for the firemen in directing a stream of water upon an object carrying electric current, was the subject of an article in a recent issue of *Energie*, of Berlin, recording the results of a number of tests. A man wearing wet shoes and standing on a wet plank flooring, threw a jet of water on an electrified plate. At 500 volts and an aperture of 0·74 inch in the nozzle, he felt the current at a distance of 2¼ feet, and with an aperture of about 2 inches could not get nearer than about 3¼ feet. Under the same conditions, but with alternating current, he could not stay within 8·2 feet, and at 3,600 volts he had to remain at a distance of 26¼ feet.

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* *Physical Review*, **15**, No. 6, December, 1902.

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

By W. E. Harrington.
General Manager Camden and Suburban Railway Company.

(*Continued from p. 120.*)

"UNITED STATES" RAIL BONDS.

The "United States" rail bond is made with solid terminals and flat strips of copper, and is so designed that it can be used inside the splice-bar of a rail-joint when the plate is only $\frac{1}{4}$ of an inch from the web of the rail. The leaves of the bond will fit into a space which is only $\frac{1}{8}$ of an inch in thickness. These features make the bond applicable to certain cases in which strands cannot be used satisfactorily. This bond is applied to the rail with a compressor. The "United States" bonds are bonds in which copper strips and welded terminals are used.

Fig. 38 shows top surface of terminal of this type of bond.

Fig. 39 shows the appearance of terminal after insertion in the hole and before compression.

Fig. 40 shows the appearance of the terminal after compression.

Fig. 41 is a section of rail web and terminal showing the result when the compression has been completed properly.

Fig. 42 is a bond of this type made in lengths from $5\frac{1}{2}$ to 14 inches inclusive. Lengths greater than 14 inches are considered special, and made only to order.

The screw compressor for applying the "United States" rail bonds is shown in *Fig. 43*.

Style "A" compressor. Weight, 83 pounds. For T- and girder-rails 7 inches or less in height. Style "B." Weight, 125 pounds. For T- and girder-rails 9 inches or less in height.

GENERAL ELECTRIC COMPANY BOND.

General Electric Company bond is made by pouring molten copper around about wire strands of body and about an iron

FIG. 38.

FIG. 39.

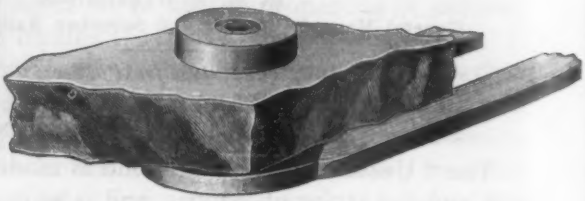

FIG. 40.

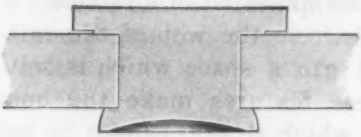

FIG. 41.

FIG. 42.—"United States" rail-bond. Style No. 3.

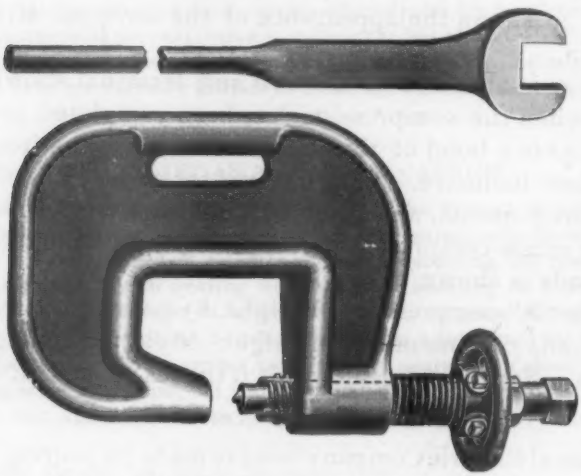

FIG. 43.—Screw compressor for applying bond.

plug, which extends through the axis of, and becomes part of the cast terminal.

FIG. 44.—*a*.

FIG. 44.—*b*.

Steel core before and after compression.

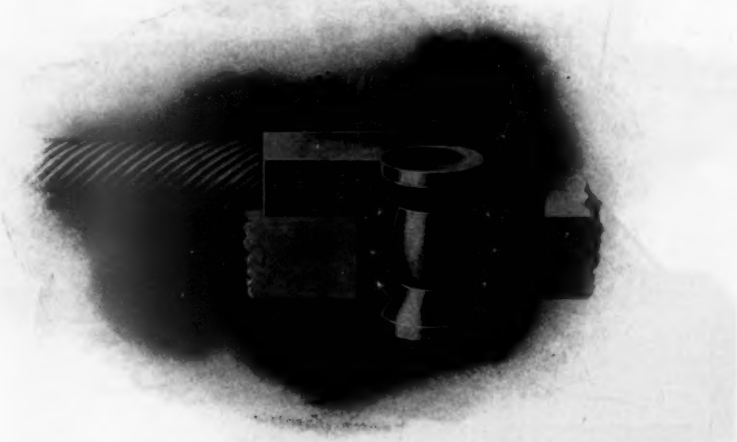

FIG. 45.—Section through rail bond showing effect of compression.

Figs. 44 to *49* show different forms and applications of this type of bond.

Figs. 50 and *51* show the soldered flexible rail bond. It

is formed of a series of flat strips of annealed copper bent in the form of an arch to ensure the greatest degree of flexi-

FIG. 46.

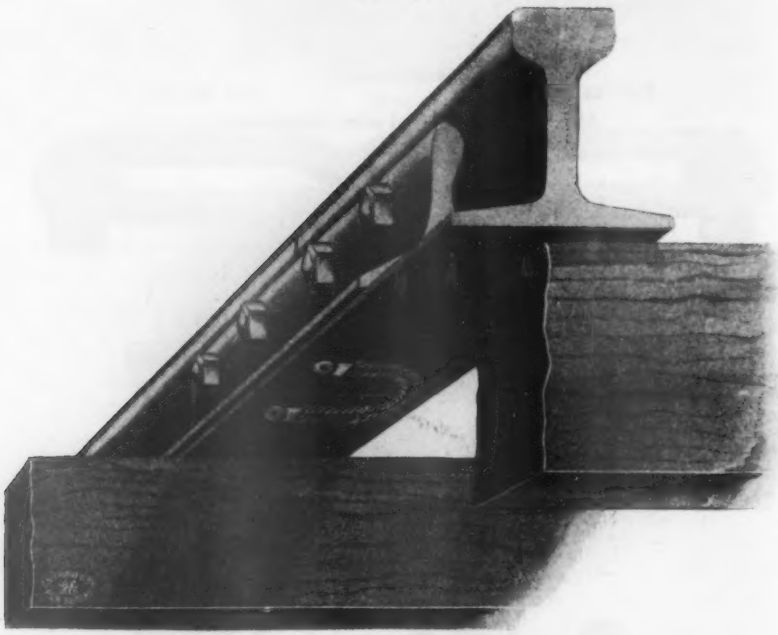

FIG. 47.—Form C bond under bottom flange for extreme flexibility.

bility, with a pair of flat feet to provide a contact surface. The strips of each foot are soldered together, making a solid terminal, while the intermediate strips of the arch are un-

attached to each other. The feet of this bond are soldered to the rails.

Outfit. An outfit for placing this bond comprises one special rail-cleaner and emery wheel, one special blow-torch, one wind-guard, clamps, solder and acid.

FIG. 48.—Form B bond under fish-plate.

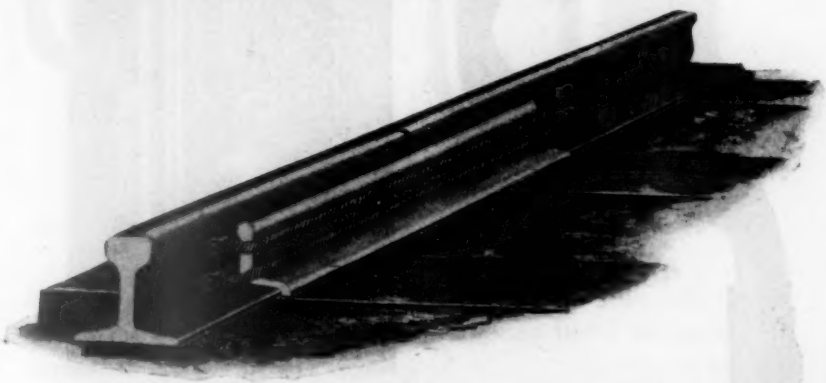

FIG. 49.—Bonds spanning fish-plate where there is insufficient room between rail and fish-plate.

Instructions for placing: (1) Clean the two surfaces of the rails where the bonds are to be applied by scraping with a file or by an emery wheel run on a flexible shaft as shown in *Fig. 52*. These surfaces must be made perfectly clean and bright, free from rust, etc., and should be slightly

FIG. 50.—Soldered flexible rail bond.

FIG. 51.—Soldered flexible rail bond.

larger in area than the contact surfaces of the feet of the bond. The bond should be bent so that the feet shall lie true on the cleaned surfaces, and should be 7 inches in extreme length when applied.

Heat is applied to these surfaces by means of a special blow-torch, *Fig. 53* (using wind-shields, *Fig. 54*, when necessary to protect the burners), until the surfaces have reached a temperature when solder will melt. This takes but a few minutes, and can be determined by rubbing a stick of solder on the heated parts. When the solder runs freely, the sur-

FIG. 52.—Hand grinder, flexible shaft and emery wheel.

FIG. 53.—Osborn torch.

faces are rubbed with a flux (preferably zinc cut with muriatic acid), then the solder is applied until the surfaces are thoroughly tinned.

The bond is placed in position, with the feet in level contact with the tinned surfaces, the strip of thin solder which is attached to the foot of the bond having first been lifted and the foot cleaned with a brush wet with the acid solution.

Heat is applied to the feet of the bonds until the layer of solder runs. A brush wet with soldering acid is then passed around the edges of the feet to bank the solder which

squeezes out, making a uniform junction between bond and rails. (Pressure should be applied to the feet of the bonds during the process. If the bonds are applied to the bottom of the rails, they are held in place with the special clamp shown in *Fig. 55*, but during the operation of bonding new construction the pressure is not applied until the solder is thoroughly melted.)

When the solder is set, the pressure is removed and the metal cooled gradually by first pouring water on the rail near the bond. Water should not be put directly on the solder

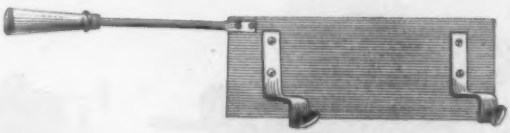

FIG. 54.—Wind-shield.

FIG. 55.—Standard clamp.

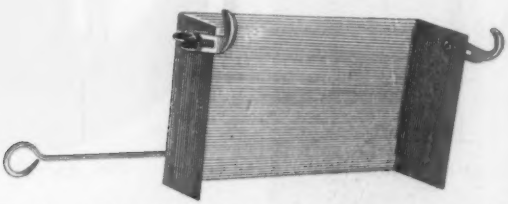

FIG. 56.—Wind-shield for bonding during construction.

until it is thoroughly set, else there is a tendency to crystallize. Finally, the bond is washed to remove all acid. The bond has now a firm and enduring contact.

In new construction where joints are to be suspended, it is best to connect together by the joints or fish-plates, about 10 rails (if 30 foot), forming a section which can easily be turned over by four men. This section is turned bottom up, and after the bonds are applied, turned back and spiked in place. Before doing this, however, each end of the section should be cleaned and tinned so that the bond connecting

the various sections can easily be applied after the track is in place.

The wind-shield and special torch employed in new construction are shown in *Figs. 56* and *57*.

AMALGAMATED BONDS.

Description. The solid copper bond, *Figs. 58* to *62*, is made of a rectangular plate of rolled electric copper, 3 or more inches long, $\frac{1}{8}$ of an inch thick (or thicker) and $1\frac{1}{2}$ or more inches high. A cup-shaped projection is pressed near each end so as to give a contact against rail-web close to the

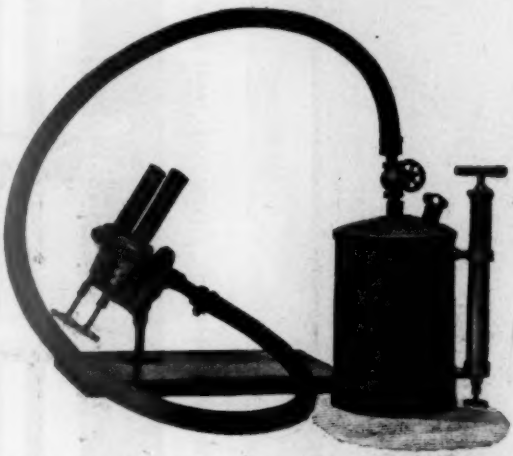

FIG. 57.—Osborn torch, with additions for underneath bonding when track is spiked down.

end of each rail. Next to the copper is a piece of sheet steel supporting a pair of special steel springs: the steel is used to keep springs from wearing into copper. These pieces are held together by a small steel staple passed over the center of bond and driven into a cork composition plate which is longer and wider than the metal and serves to exclude dirt from the contact surfaces and to hold the springs in position.

All metal parts of bond are amalgamated to prevent rusting, and the contact surfaces are covered with plastic alloy. The bond is always laid out to suit each particular rail and joint, and does not interfere with the mechanical

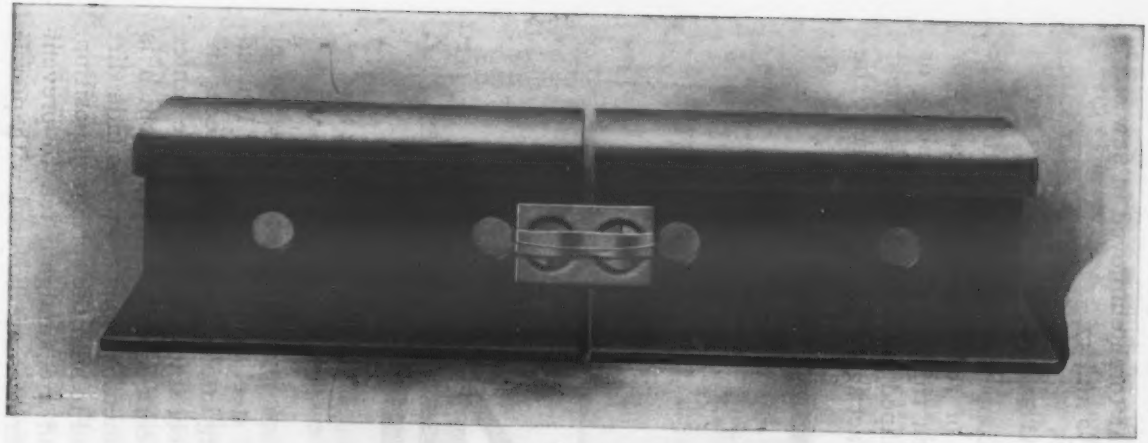

FIG. 58.—The solid copper bond without cork, ready for angle-plate.

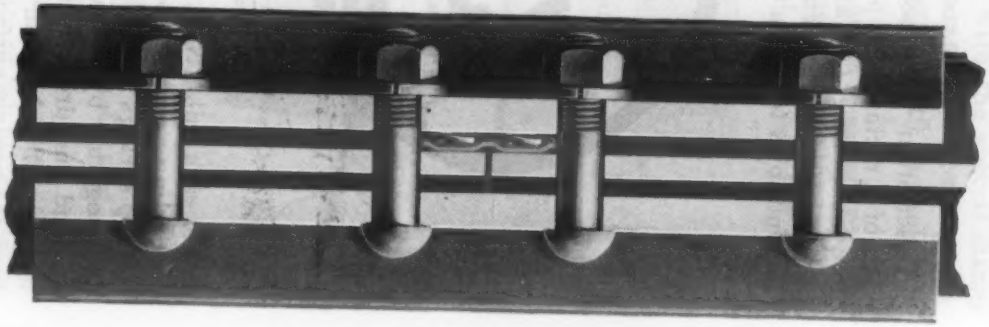

FIG. 59.—Horizontal section through center of bond.

fit of angle-plate. When in service the springs serve merely as distance pieces so long as joint is tight; if nuts loosen or plates wear, the springs still hold bond in contact. Then tightening the track nuts also tightens the bond. The use of spring-lock washers is advised on track nuts to

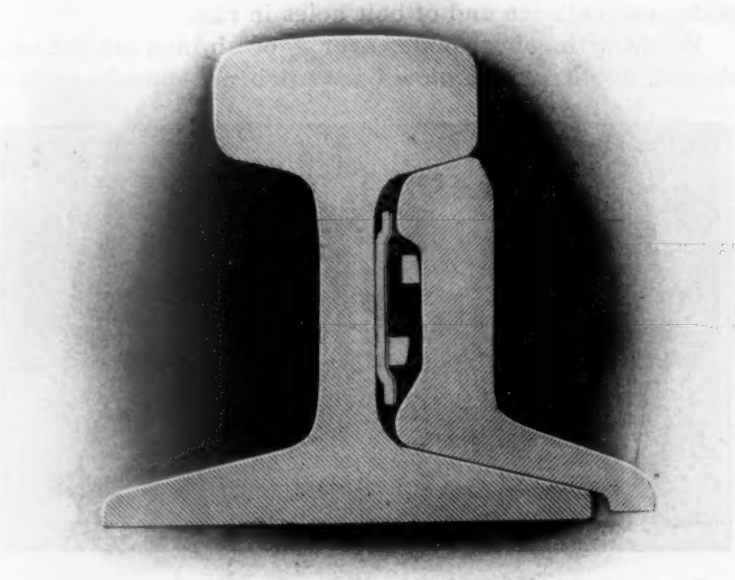

FIG. 60.—Vertical section through center of bond contact.

keep them fast; these washers will then take up the wear of the plate.

Where clearance between web of rail and angle-plate will not permit the use of springs, a plate of flexible cork is placed so as to overlap the copper on top, bottom and sides and give sufficient pressure to maintain the contacts. (See *Fig. 61.*) Another cork plate is placed between rail-ends to keep out dirt.

To apply this bond it is only necessary to brighten web

of rail beyond end bolt hole with a hand-power grinder and flexible shaft with emery wheel. The surfaces are then amalgamated and covered with a thin layer of plastic alloy. The lubrication afforded by the plastic alloy permits the rails to move in any direction without wearing away metal of bond.

Sizes. The size of copper is varied to suit requirements up to the full area of the space between rail-web and angle-plate, and between end of bolt holes in rail.

Bonds with copper plates over $\frac{3}{16}$ of an inch are not cup-shaped, but have a shallow outward bend opposite ends of

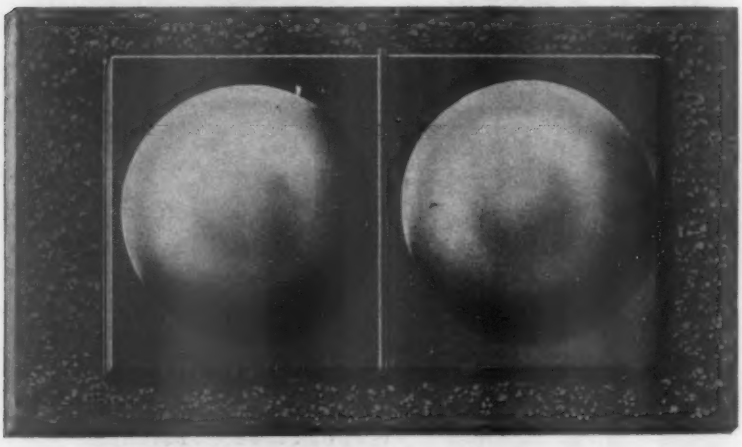

FIG. 61.—Front of No. 5/0 solid copper bond, full size, with cork plate.

the rails; this avoids scraping bond against sharp rail edges.

The bond shown in *Fig. 61* has a vertical cross-section of more than 0·218 of a square inch, while the section of a No. 4/0 wire is but 0·166 of a square inch. The bond, therefore, has a greater conductivity than $1\frac{3}{10}$ No. 4/0 copper wires.

Conductivity. It has been claimed that one No. 4/0 solid copper bond laid upon amalgamated contact spots on head of 80-pound T-rail so as to bridge the joint, carried 2,000 amperes with a drop of ·018 volt. The drop of 1 inch of this rail with the same current was ·00223 volt. The

bond merely laid on top of rail and held in contact by *nothing but its own weight* was equal in resistance to but 8¼ inches of rail. The drop of unbonded joint, with same current, was ·423 volts.

Guarantees. Manufacturers guarantee that the bond will transmit current at the rate of 2,000 amperes per square inch of vertical section without heating beyond temperature of rail.

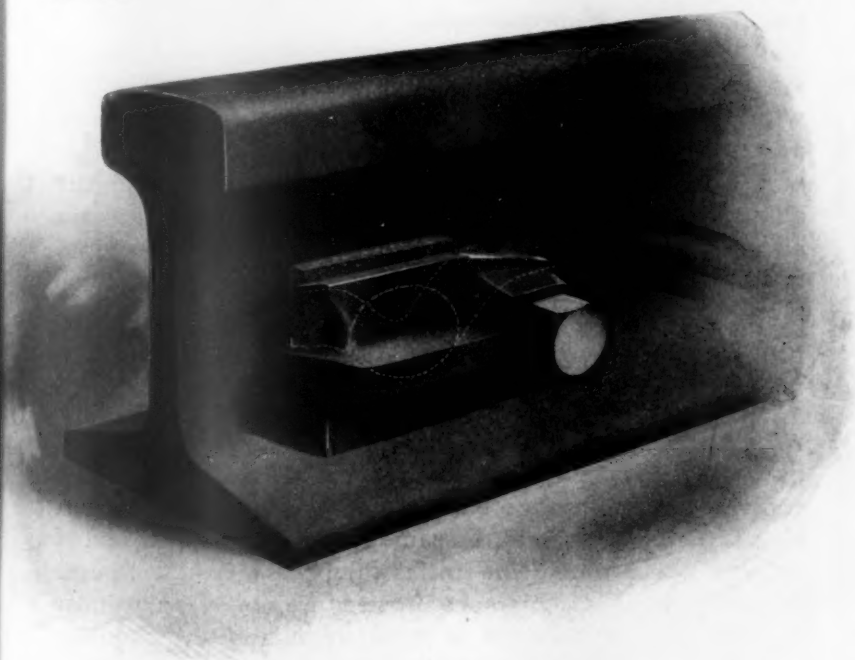

FIG. 62.—Cast-iron feeder terminal.

They further guarantee under above conditions that at the end of two years' service, the conductivity of the bond will be practically the same as at the start, provided the joints have been mechanically maintained in proper condition for operating cars.

Cross Bonds. Copper cross-bond terminals for No. 2/0 and No. 4/0 wires. These are fastened to rail web with ⅝-inch bolts, whose ends should be riveted after nuts are set tight. The end of the wire is amalgamated and slipped

through hole in lug upon bottom of terminal. A round-nosed tool is placed at right angles to wire in the hole below bolt-hole and the wire kinked by a hammer blow, forcing it into a cored cavity. The hole is then filled with plastic alloy and the terminal bolted against amalgamated contact spot on rail web.

On exposed road where copper track wire might be stolen, use a steel cross bond $1\frac{3}{8}$ inches square, which cannot be removed without special tools.

For rail feeders and loops around crossings, switches and special work, use cast-iron terminals for one or two No. 4/0 wires and for 250,000 and 500,000 C.M. cables. These hold a cork case against web of rail, forming a receptacle into which is placed the end of the wire and some of the plastic alloy. In each case the wire ends are amalgamated, as are also the contact spots on web of rail. These terminals are fastened to rail web with $\frac{3}{4}$-inch bolts, whose ends should be riveted after nuts are set tight.

PLASTIC RAIL BOND.

For track with heavy rail and angle plates, this bond, *Figs. 63-66*, is composed of two portions: a plastic alloy or putty-like metal compound which makes contact between the rail and the splice bar or angle plate, and a flexible, elastic cork case to hold the same in position as near end of the rail as possible. The initial thickness of the cork case is nearly double the distance between web of rail and inner surface of angle plate; it is therefore compressed about 40 per cent. when in place and after pressure has been applied it adheres to the rail and plate, completely sealing the plastic alloy.

The cork case is made of a compound of cork and oxidized linseed oil and is practically indestructible. It is elastic and will maintain seal even when plate has loosened $\frac{3}{16}$ of an inch.

The current passes from one rail through one plug to the angle-plate, and then through second plug from the plate to the next rail (see arrows in *Fig. 73*). Contact spots about 2 inches in diameter on both rails and angle plates are

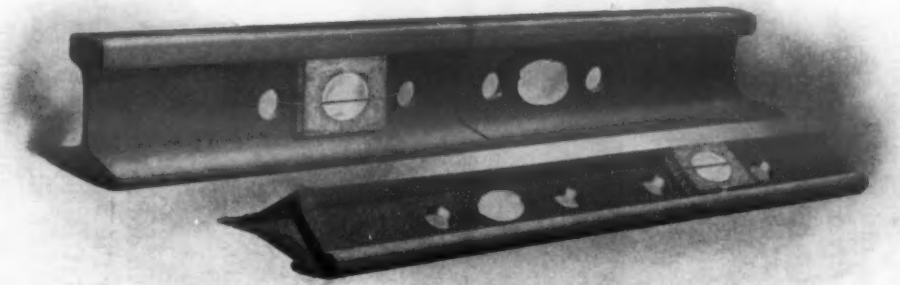

FIG. 63.—Plastic rail bond ready for application.

FIG. 65.—Completed joint with plastic plug bond.

cleared of scale and rust and treated with the solid alloy, which instantly silvers the surfaces and prevents them from rusting. This fills the surface irregularities and penetrates the metals for a perceptible distance, leaving a surface to which the plastic alloy adheres.

Plastic-plug Rail Bond. This can be used on all forms of rail where the fish-plate overlaps rail base by 1 inch or more. Several different forms to meet varying requirements are shown in accompanying cuts, *Figs. 65–66.*

The application of the plastic-plug bond is made after the completion of the track, so that delay through interference of two different gangs is avoided. Between the first and second bolt holes from the end of each rail, a hole $\frac{7}{8}$ to

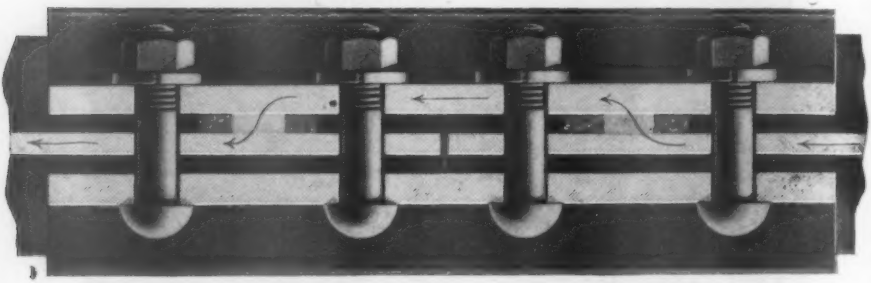

FIG. 64.—Horizontal section.

$\frac{7}{8}$ of an inch in diameter is bored diagonally downward through the flange of angle plate, into, but not through, the base of rail.

The hole is nearly at right angles to plate flange and as near the vertical web as possible. An ordinary ratchet drill and a J-shaped clamp passing under the base of rail are the only tools necessary. The drill point is lubricated with a solution of pearline and water instead of oil, so as to avoid the trouble which follows the use of an insulating fluid on metal contact surfaces, and the hole is usually drilled to $\frac{1}{8}$ of an inch from bottom of rail base. The drill chips are removed with a permanent magnet, and the proper depth determined by template or collar fastened on drill. The plates may be drilled before distributing along the road;

this is more than double the number of joints which can be bonded in a day.

After the hole is drilled it is amalgamated by filling with water and rubbing with the end of a rod of the solid alloy. On bonds of large diameter, an amalgamated copper tube is driven into the hole so as to completely seal the crack between the meeting surfaces of rail and angle-plate as shown on right side of *Fig. 12*. This is unnecessary with the small sizes. The hole is then partly filled with the plastic alloy, which adheres to the amalgamated surfaces of the steel.

An amalgamated copper plug, which is T-shaped in section, is then driven to seal the hole and to complete the

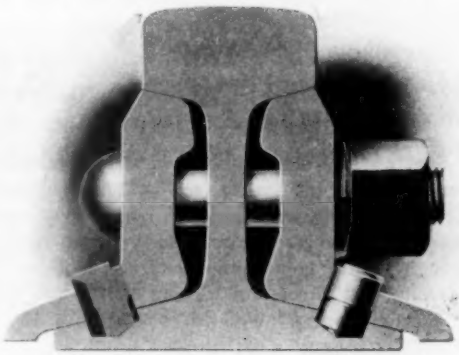

FIG. 66.—Section of plastic plug bond.

circuit between the rail and angle-plate by dipping into the plastic alloy. It is locked in place by a hammer blow on a blunt chisel, making a burr in angle-plate just above the top of the plug.

Fig. 65 shows completed joint with standard plastic-plug rail bond. *Fig. 66* shows section of same. In one form of this bond the lower part of the plug is a little out of center with the top, since less clearance is required on the inner side of hole because further motion of angle-plate inward can occur only after rail and plate surfaces have worn. This eccentricity allows a groove to be made in top of the plug, and this groove should always face the outside of the rail. The grooves serve to prevent air binding as plug is driven

home, and are then closed by a tap of the hammer on the edge.

There is a modification called the plastic screw plug for very heavy rails carrying steam road service on bridges and in tunnels, in which provision is made for easy examination and repair. The hole in plate is of larger diameter and is screw-threaded and amalgamated before distribution along the road. A hardened steel jig is screwed into hole to properly locate rail drilling. When this hole is drilled and amalgamated a copper tube is driven home and around the top of the tube is placed a diagonal strip of elastic packing. The hole is then partly filled with the plastic alloy and the plug screwed down to compress the packing and seal the joint.

[*To be concluded.*]

SELF-HARDENING STEELS.

One of the recent notable developments in the metallurgy of steel has been the manufacture of what is known as self-hardening or high-speed steels, which are adapted for tools working at a high rate of efficiency. There is a great variety of these steels on the market, and they show wide differences in composition, although usually containing some of the rarer metals, such as tungsten, molybdenum and chromium. Tools made from these steels can work without injury at a temperature of 500° or 600° C.

THE MT. VESUVIUS RAILWAY.

What is said to be the most dangerous railway in the world is that recently completed up the side of Mt. Vesuvius for the benefit of the many tourists who annually visit this famous volcano. It is a cable railway of the monorail type, the one car comprising the active rolling stock being supported by two wheels, one at each end of the car. The center of gravity of the car is below the top of the supporting rail, so that it balances without the aid of supporting wheels at the sides. The railway line runs to within nominally 1,000 feet of the crater mouth, but the distance changes from day to day on account of the rapid changes that take place; accretions to the sides of the crater may materially increase the distance one day, and the fall of a huge slice into the seething gulf 500 feet below may considerably lessen the distance the next day. The maintenance of the line in proper alignment is a difficult matter. Fissures opening, the flow of lava, falling cinders, and sliding of the roadbed require constant watchfulness and labor by gangs of laborers who constantly patrol it during the periods of operation. The "train" has no fixed time-table, the trips depending on the activity of the volcano and direction of the wind; some days they are entirely abandoned.—*Machinery.*

CHEMICAL SECTION.

Stated Meeting, held Thursday, October 15, 1903.

A Basic Reaction of Aromatic and Fatty Aldehydes.

By Samuel S. Sadtler.

While carrying on some work in oils of orange and lemon, I found it very difficult to get accurate determinations of the citral in certain of these oils. They were so-called oleo-resins of orange and lemon, which contain a relatively large percentage of acid resins, and have not to my knowledge been, as yet, described. These oils are obtained by extraction with a volatile solvent, which seems to dissolve certain constituents from orange and lemon peel, which either are not extracted at all, or else in smaller proportion by the processes of expression. It is recorded as a fact that the gravity of machine-expressed oil is greater than hand-pressed, and these oils are heavier than either.

With the use of sodium bisulphite for determining the aldehydes the addition compound forms partly in the aqueous layer and partly in the oily layer, and further work is very discouraging when this stage is reached. I soon tried sulphite of soda instead of the bisulphite. On heating a solution of this with the oil, the dihydrodisulphonate of sodium is formed, which is soluble in water, and two molecules of sodium hydrate are split off. Tiemann, in his work on the aldehydes of lemon-grass oil, pointed out that the reaction could be indicated by phenolphtalein, and by adding a solution of sulphurous acid from time to time, the end of the reaction could be known and the difference of volume of the oil could be told. This, however, is not a method that is capable of the greatest accuracy, and requires a special form of flask.

It occurred to me that the alkali formed in this reaction might be titrated for with standard acid, omitting the bicarbonate of sodium used by Tiemann. I first tried this with a standardized solution of sulphurous acid, but later found

N/2 HCl, or normal HCl, very satisfactory and more convenient. It seems to require the use of more sulphite solution, however, as the sulphurous acid reforms sulphite from the NaOH split off. I will try, however, at a future time, to take up all the details necessary in the determination of citral as a matter by itself, and speak of the general procedure more especially at present.

From other tests on the oils in question, I found that they contained considerable quantities of acid resin, which would, unless previously neutralized, interfere with the results. In fact, I found the acid resin of the orange oil almost sufficient to neutralize all the alkali formed. This difficulty was overcome by neutralizing these acids first with dilute caustic potash solution (N/2KOH being convenient for the purpose, and if done quantitatively, might be interesting as part of a more or less complete examination of the oil) and rosolic acid solution as indicator, which will serve as indicator in the subsequent reaction.

Analyses were made with oil of orange, but until the mixtures of aldehydes of this oil are more fully studied, I will not refer to figures obtained. If citral is not found to be the predominating aldehyde, the results would be of little value except as comparative.

For oil of lemon, 5 or 10 grams are weighed into an Erlenmeyer flask, and after neutralization, 25 or 50 cubic centimeters of a 20 per cent. sodium sulphite solution, depending upon the amount taken, is added. Before adding the sulphite solution, however, it is neutralized with a little N/2HCl, after being heated by immersion in a water bath. The sulphite solution used in these experiments required about ·75 cubic centimeters of N/2HCl to neutralize at boiling temperature, with rosolic acid as an indicator. When the solutions were mixed a red color formed at once in the aqueous layer. This was discharged from time to time with N/2HCl. The flask is then heated and agitated frequently. The reaction is complete in about half an hour, if kept hot, and the layers mixed frequently. When the color is all discharged, or all but a very faint pink, which is not appreciably affected by a few drops more of acid.

the number of cubic centimeters of standard acid is noted. An emulsion forms, due to the neutralized resins, but that does not interfere with the reaction, if care is exercised.

The reaction, as written by Tiemann, is:

$$C_9H_{15}COH + 2H_2O + 2Na_2SO_3 = C_9H_{17}COH(NaHSO_3)_2 + 2NaOH$$

and is probably correct, as the amount of citral and sulphite is shown below to be in the ratio of 1 to 2.

The amount of standard hydrochloric acid used expressed in terms of citral, in the above ratio of one molecule of citral to two molecules of HCl, divided by the weight of oil taken, gives the percentage of citral.

Analyses of citral in lemon oil, by this method, gave in two determinations:

	Per Cent.
I.	5·24
II.	5·29

I believe results within one or two tenths of a per cent. can be gotten in every case, with a little practice, by this method.

To check the accuracy of this reaction, I made some known mixtures of citral, which was kindly furnished by Dr. Harry F. Keller, and separated lemon-oil terpenes, previously freed from citral.

	Calculated.	Found.
I.	8·68	8·85
II.	12·11	12·15

The method was further checked by using some pure well crystallized vanillin (M. P., 81° C.). The phenolic hydroxyl of the vanillin was first neutralized with a little caustic potash solution until it became a faint pink, using a little rosolic acid, sulphite solution added and titrated hot with N/2HCl, having first neutralized the sulphite solution at water-bath temperature as in the case of citral.

	Calculated.	Found.
Vanillin	100·00	99·00

This was a rough check on the method, but as the vanillin had not been specially purified further examination

of the reaction with vanillin, vanilla extract, and samples of vanillin mixed with coumain and acetanilid will be undertaken.

The reaction is almost complete in the cold with vanillin and merely needs heat to complete the reaction more quickly. Standing a short time might have given the same results.

The reaction seems to be immediate and complete with fatty aldehydes. It will indicate the presence of 1 part of formaldehyde in 1,000,000 parts of water, and when contained in food products the formaldehyde can be detected in a distillate of the same. The writer was able to detect formaldehyde in a solid product, partly made from milk, by first distilling with steam, neutralizing any free acid in the distillate with alkali, adding neutral sulphite solution and indicated upon which the presence of NaOH found in the reaction is clearly shown and can be accurately titrated for by means of standard acid.

Besides detecting and determining formaldehyde in milk a neutral sulphite solution used as a reagent is very useful.

The presence of acetone may be detected in wood spirits and determine acetic aldehyde in grain spirits. I noticed that a sample of grain alcohol, which, even after being carefully distilled over lime, gave a very brown color when made up into alcoholic potash, gave a very strong red coloration when mixed with sulphite solution and phenolphtalein.

Acetone and higher ketones were found to react, but further work on the various applications of this reaction must be taken up with the various substances in detail.

Referring again to essential oils, the reaction seems to be applicable to any essential oil, the single or predominating constituent of which is known, such as cinnamon, bitter almond oil, lemon-grass oil, cassia, etc.

PHILADELPHIA, October 1, 1903.

Correspondence.

DOES CAST IRON GROW?

To the Committee on Publication:

GENTLEMEN.—I address you herewith in regard to the interesting paper read by Mr. Alexander E. Outerbridge, Jr., at the Section meeting, held Thursday, January 7, 1904.

The title, "Recent Investigations and Discoveries in Cast Iron," is well chosen; but there is a certain enigma in it which this able metallurgist was not able to solve nor account for.

Of course, under such conditions, chemists as well as physicists hide themselves most successfully behind the molecules or the atoms, some kind of an hypothesis, which may be used for further attempts to find the truth, if possible. Mr. Outerbridge has found that *iron will grow*, when repeatedly heated and slowly cooled, a fact long since known, but never explained satisfactorily by a physical cause. The many experiments and measurements recorded by Mr. Outerbridge are well worth reading; and, as in some cases a growth or expansion of 35 per cent. in cubical dimensions occurred, certainly gives the reader something to think about. (See *Jour. Frank. Inst.*, February, 1904, page 133, *et seq.*)

Now, the remarkable growth in cubical dimensions of cast iron on repeated heating ought to be explainable on physical grounds.

The following short story will show my view on the subject:

On Thursday, February 4, 1904, Dr. William Campbell, of Columbia University, New York, delivered a lecture before the Mining and Metallurgical Section, on "Results of a Research on the Structure of Metals and Alloys." He illustrated the lecture with a large number of well-prepared slides.

I don't think I ever saw better slides prepared; indeed, they were exceptionally good, inasmuch as every detail could be recognized of the structure of the metal specimen photographed; so much so, that the crystallizations were so well defined that I, for my part, was delighted to see them.

Now, there was a slide in which the cast-iron plate after polishing must have been well washed; because I saw longitudinal depressions or holes which were perfectly clean and, strange to say, reflected light from within. There was not only one, but a good many; I could not count them, since one slide followed the other at short intervals. These hollow spaces may have been looked upon as if they had been crystals or some of the eutectic mass; but to my vision they were hollows or cavities.

You may depend upon it, that those cavities were formed by a gas or a mixture of gases during the preparation of the iron.

Assume now, if you please, any piece of cast iron having cavities filled with any mixture of gases which cannot escape when cold nor when heated; is it then to be wondered that the gases will expand in all directions within the vessel in which they are enclosed? and is it any wonder, that by every renewed heating the gases will re-expand and will exert the high pressure against the cast iron in which they are enclosed? This seems to me to be the

fact in regard to the growth of a piece of cast iron when heated repeatedly; then, so long as the heating will be repeated the growth or the expansion of the cubic contents of the piece of iron will continue? No! there must be a limit to the action of the gas, and that is when the cavities become too large and the pressure on the iron walls of the cavities must cease.

Yours respectfully,

E. GOLDSMITH.

658 N. TENTH STREET,
PHILADELPHIA, February 11, 1904.

Notes and Comments.

ELECTRIC RAILROAD CAR LIGHTING IN GERMANY.

As a result of many tests of various systems of railroad car lighting in Germany, the Prussian State Railway Administration has finally settled on a direct system of lighting from a single generator with a steam-driven dynamo, located on the locomotive, under the control of the engineer; also auxiliary or regulating storage batteries placed on each car of the train, thus rendering the lighting system on each car practically independent, its lights being assured a constant supply of current from its own accumulators, which accumulators are kept charged by the dynamo on the locomotive. It is stated that this combination meets more perfectly than any of the others the requirements of simple, economical and efficient construction, maintenance and attendance in regular service.—*Iron Age.*

ACETYLENE FROM CALCIUM CARBIDE.

A yield of 5 cubic feet of acetylene gas from every pound of calcium carbide is guaranteed by manufacturers in the United States. In Germany acetylene gas is mixed with a gas of lower candle-power, containing about 25 per cent. acetylene, and used in railroad cars.—*Engineering and Mining Journal.*

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, February 17, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 17, 1904

Vice-President JAMES M. DODGE in the chair.

Present, 106 members and visitors.

Additions to membership since last report, 16.

The following resolution was adopted with unanimity:

"*Resolved*, That the President and Secretary be directed to extend to our sister Society, the Maryland Institute for the Promotion of the Mechanic Arts,

in Baltimore, the sincere regrets and sympathy of the Franklin Institute for the misfortune it has suffered in the destruction by fire of its building and equipment, and to express the hope that the Maryland Institute may speedily recover from this disaster, and enter upon a new career of usefulness."

The discussion announced for the evening was opened with a brief paper by Mr. Charles Day, on "The Electric Motor in the Machine Shop," which was illustrated by a number of lantern photographs, showing a variety of modifications of motor driving, adapted to meet the varying conditions found in machine shops.

Mr. Day was followed by Mr. H. B. Emerson, of the General Electric Company, Schenectady, N. Y.; Wm. Cooper, Cincinnati; Prof. Wm. D. Marks and others.

Mr. C. J. Reed described and exhibited in operation a "Variable Speed Controller" of his invention, which is designed to meet the requirements of motor driving.

The paper, with discussion thereon, has been referred for early publication.

The recent destructive fire in Baltimore was the subject of comment by Mr. Wm. McDevitt, Chief Inspector of the Philadelphia Fire Underwriters' Association, Dr. Henry Leffmann and Mr. Louis E. Levy. The latter exhibited and explained a number of lantern photographs, which illustrated the character and extent of the conflagration. Dr. Leffmann made a comparison of the areas covered by a number of the great fires in various cities of the world, which have become historic by reason of their magnitude and destructiveness. Mr. McDevitt treated the subject from the viewpoint of the fire and insurance expert.

The chairman announced the appointment of the several standing committees of the Institute for the current year.

Adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

(*Abstract of the proceedings of the stated meeting held Wednesday, February 3, 1904.*)

MR. CHAS. E. RONALDSON and PROF. LEWIS M. HAUPT in the chair.

Prof. Lewis M. Haupt was elected chairman of the committee for the current year.

The following reports were acted on:

(No. 2164.) *Steam Generator.* John C. Parker, Philadelphia. Final action postponed.

(No. 2246.) *Enclosed Arc Lamp.* John Allen Heany, Philadelphia. Referred back to sub-committee.

(No. 2255.) *Joint for Rail-bonding.* C. B. Voynow and H. B. Nichols, Philadelphia.

ABSTRACT.—This method of making joints for electric railways is the subject of letters-patent of the United States, Nos. 673,649 and 673,829, May 7, 1901. It consists essentially in a preliminary cleaning of the parts of fish-plates and rail ends from scale, etc., by means of the sand-blast, and then pouring into the joint molten zinc, to make a firm union of the parts and a joint of high electric conductivity. All the mechanical details of the operation are cleverly worked out with the aid of a portable outfit of drilling and reaming machines, sand-blast apparatus and spelter-melting and pouring vessels. The details cannot be more fully described without illustrations.

The system has been adopted by the Philadelphia Rapid Transit Company with success. The report gives an account of a series of electric tests of resistance of the Voynow-Nichols joint conductor for the committee by Prof. Arthur J. Rowland in the Electrical Laboratory of the Drexel Institute, and of a physical examination made by members of the committee over a considerable section of track. These tests yielded very satisfactory results.

The report concludes that this joint has the advantage over other continuous rail joints of being easily removed and replaced, and the material removed does not become scrap, but is available (except the rivets) for use in other joints. In view of the completeness of the way in which the invention—method and apparatus—has been worked out, the award of the John Scott Legacy Premium and Medal has been recommended to the inventors. (*Sub-Committee.*—T. Carpenter Smith, Chairman; Richard Gilpin, E. A. Scott.)

(No. 2279.) *Electric "Buzz" Fan.* S. S. Wheeler, New York. Action deferred.

(No. 2283.) *Under-feed Stoker.* Evan Wm. Jones, Portland, Oregon.

ABSTRACT.—This is a device for feeding fuel to a fire from beneath, and has been applied with conspicuous success to the furnaces of steam generators using soft coal, the system operating as a mechanical stoker to supply the fuel to the furnace automatically, and to consume it without the production of notable amounts of smoke.

The report is reserved for publication in full with illustrations, without which a detailed description would be unsatisfactory.

The invention is protected by a number of patents, of which United States patent No. 409,792, granted to E. W. Jones, August 27, 1889, covers the fundamental principles.

The report concludes: "In view of the fact that Mr. Evan W. Jones has done such good work in . . . the design of the under-feed stoker under consideration, and in view of the simplicity of the device from a mechanical standpoint, both in construction and operation," the award of the John Scott Legacy Premium and Medal is recommended. (*Sub-Committee.*—Kern Dodge, Chairman; James Christie, Henry F. Colvin, John M. Hartman.)

(No. 2298.) *Rapid Roller Copier.*—Yawman & Erbe Manufacturing Company, Rochester, N. Y.

ABSTRACT.—This machine is a device designed for the purpose of easily and rapidly copying letters, manuscripts, etc. The copying is done from an endless web of paper which, in operation, is automatically moistened by passing beneath a roller immersed in a vessel of water, and then pressed together with the letter or manuscript to be copied, between feeding and

pressing rollers. The machine is mounted on a convenient stand, and appropriate means are provided for regulating the tension on the copying paper, the proper alignment of letter and copying paper, etc.

The details cannot be more fully described without illustrations.

The report finds that this copier is intelligently and carefully designed and is a practical machine. It is protected by patents. The award of the Edward Longstreth Medal of Merit is granted to the manufacturers, the Yawman & Erbe Manufacturing Company. [*Sub-Committee.*—E. W. White, Chairman; Luther L. Cheney, Geo. S. Cullen, Louis E. Levy.]

(No. 2305.) *A Simplified System of Pitman Phonography.*—Francis J. Stein, Philadelphia.

ABSTRACT.—This system is described in a manual by applicant entitled a "College Course of Shorthand." The most radical change from the Pitman system is in the arrangement of vowels in respect to their position, and the resulting position of words.

Applicant abandons the method of regulating the position by the sound of the vowel, and substitutes a classification of the letters themselves without regard to their sound, thus ignoring the phonetic system so far as the vowels are concerned. The first group consists of all the sounds of the vowel *a*, and occupies first place, or above the line; the second comprises all the sounds of *e* and *i*, and occupies the second place, or on the line; the third comprises all the sounds of *o* and *u* and the diphthongs *oo*, *ou*, and *oi*.

The result is to change the position of the majority of the words of the language; but as the student has no knowledge of prior systems the new position creates no difficulty. The author claims for this the student is not hampered by the necessity of learning the various sounds of the vowels, and that he can without hesitation place the word in its proper place.

The obvious objection to this change is that words identical in their consonant outlines may be mistaken for one another, but the author claims that such cases would be few.

In the consonant signs, the principal change made by the author is in making the *l* and *r* hooks on the same side of the stems, distinguishing them by making the former uniformly large and the latter uniformly small. For this change increased speed and legibility are claimed.

Applicant takes the broad ground that fully 90 per cent. of those who learn shorthand do not need to know the requirements of the phonetic vowel scale, and that a lack of that knowledge will not prevent them from acceptably filling business positions.

The Committee recognizes the fact that facility in shorthand writing depends not so much upon the system as upon the thoroughness with which it has been learned and practiced, and that no great speed or accuracy can be attained until the forms can be written without conscious effort.

In consideration of the practical character of the manual, and the fact that the system has proved in practice to be a ready means of teaching shorthand to comparatively young pupils, a Certificate of Merit is awarded to the author. [*Sub-Committee.*—E. A. Scott, Chairman; Geo. B. Cock, George S. Cullin.]

(No. 2306.) *Nut-Lock.* James Walsh, Jr., Philadelphia.

An advisory report. W.

Sections.

[*Abstracts of stated meetings.*]

MINING AND METALLURGICAL SECTION.—*Stated meeting*, held Thursday, February 4, 1904, 8. P.M. Mr. James Christie in the chair. Present, 38 members and visitors.

Dr. William Campbell, of Columbia University, New York, read a paper describing the "Results of a Research on the Structure of Metals and Alloys." The speaker illustrated his remarks by the exhibition of numerous micro-photographic views, showing the microstructure of a number of metals and alloys.

The paper was freely discussed by Drs. E. Goldsmith, Joseph W. Richards, and the author.

Prof. O. C. S. Carter, of the Central High School, followed with an interesting informal address, describing the Silicified Forest of Arizona and the Physical Geography of the so-called Painted Desert. His remarks were illustrated by numerous lantern photographs.

The thanks of the meeting were voted to the speakers of the evening. Adjourned. (To be published.)

G. H. CLAMER,
Secretary.

ELECTRICAL SECTION.—*Stated meeting*, held Thursday, February 11th. Mr. Thomas Spencer in the chair. Present, 48 members and visitors.

Mr. Adolphus A. Knudson, of New York, presented a paper on "The Corrosion of Metals Underground by Electrolysis."

The speaker illustrated his remarks by the exhibition of numerous lantern views. The subject was discussed by Messrs. Carl Hering, Spencer Fullerton, Thomas Spencer, and the author.

The Chairman extended the thanks of the meeting to the speakers of the evening, and the session was adjourned. (To be published.)

RICHARD L. BINDER,
Secretary.

CHEMICAL SECTION—SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Joint Meeting*, held Thursday, February 18th, 8 P.M. Dr. Henry Leffmann in the chair. Present, 42 members and visitors.

Mr. Robert Job, of Reading, Pa., Chemist to the Philadelphia and Reading Railway Company, presented the "Results of an Investigation of Paints for the Protection of Structural Work." The author's results were derived from an extended microscopic study of paints of various standard compositions, and of the various materials (barytes, gypsum, clays, etc.) used as "fillers." The subject was illustrated by the exhibition of a series of photographs projected on the screen.

A lengthy discussion followed. (The paper is reserved for publication.)

W. E. RIDENOUR,
M. I. WILBERT,
Secretaries.